LAND DEGRADATION ASSESSMENT IN MOYAMBA AND PUJEHUN DISTRICTS, SIERRA LEONE

2022

Technical Report

PROJECT TITLE

Land Degradation Assessment in the Moyamba (Lower Banta and Upper Banta) and Pujehun (Malen and Makpele) Districts, Sierra Leone

MARCH 14, 2022

SIERRA LEONE AGRICULTURAL RESEARCH INSTITUTE

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Acronyms and Abbreviations

µg/L	Micrograms per Litre
CBPP	Community-Based Participatory Planning
CFSVA	Comprehensive Food Security and Vulnerability Analysis
COVID-19	Corona Virus Disease 2019
CSPro	Census and Survey Processing System
dS/cm	Decisiemens per Centimetre
DTPA	Diethylenetriaminepentaacetic acid
ECI	Employee and Company Interview
EDTA	Ethlylenediaminetetraacetic acid
ENVI	Environment for Visualising Images
ETM+	Enhanced Thematic Mapper plus
FAO	Food and Agriculture Organization
FCC	False Colour Composite
FGDs	Focus Group Discussions
GDP	Gross Domestic Product
GoSL	Government of Sierra Leone
GPS	Global Positioning System
GTZ	German Technical Corporation Agency
IAEG	Inter-Agency and Expert Group
ITD	Inter-Tropical Discontinuity
KCl	Potassium Chloride
Kg	Kilogram
KII	Key Informants Interviews

LDA	Land Degradation Assessment
LULC	Land-use and Land-cover
MACs/MNACs	Multinational Agricultural Companies/Communities
MAF	Ministry of Agriculture and Forestry
MALOA	Malen Land Owners Association
Mg	Milligram
Mg/L	Milligrams per Litre
MMRD	Mixed Method Research Design
NGOs	Non-Governmental Organizations
NPK	Nitrogen, Phosphorus and Potassium
OLI	Operational Land Imager
ONS	Office of National Security
PPP	Purchasing Power Parity
SDGs	Sustainable Development Goals
SLARI	Sierra Leone Agricultural Research Institute
SLL	Monetary unit of Sierra Leone
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNPBF	United Nations Peace Building Fund
USD	United Sates Dollars
USGS	United States Geological Survey
WFP	World Food Programme
µS/cm	Microsiemens per Centimetre

An Overview of SLARI

The Sierra Leone Agricultural Research Institute (SLARI) was established through an Act of parliament in 2007 as a semiautonomous state institution, as part of the government's efforts to strengthen agricultural research. In order to align its research activities to the government's agenda on food security, economy diversification, poverty reduction, employment creation, and commercialization of the agriculture sector, SLARI has developed a Strategic Plan which identified five key result areas to deliver on the institute's specific objective of generating and promoting innovative agricultural technologies and the empowerment of all stakeholders.

The five result areas in the SLARI Strategic Plan are as follows (i) Appropriate agricultural product value chains technologies and innovations generated and promoted; (ii) Appropriate markets and marketing strategies for enhancing agricultural product value chains developed and promoted; (iii) Appropriate policy options for enhancing agricultural product value chains facilitated and advocated; (iv) Capacity for implementing agricultural product value chains research strengthened; and (v) Appropriate mechanisms for managing, sharing and up scaling agricultural knowledge, information and technologies established and operationalized.

This Strategic Plan emphasises the need for SLARI, as a national research institution, to work with partners, collaborators, the farming community and other key players along the various value chains to achieve a vibrant commercially oriented and competitive agricultural sector. To achieve the goal of this Strategic Plan, seven research centres have been established by SLARI with mandates on crops, livestock, fisheries, forestry, and environment management.

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Executive Summary

Land degradation is one of the major challenges confronting the global development agenda and its impacts have been manifested in several ways including loss of soil fertility, pollution, and loss of ecosystem services like carbon sequestration, flood protection, and water supply. The loss or decline of the productive capacity of natural resources has huge implications for not only the sustainability of indigenous livelihoods but also human health and wellbeing.

In Sierra Leone, mining is perhaps the most notable proximate cause of land degradation, and it is the most easily linked to reductions in arable land and decline in soil fertility. In addition to its impacts on food security and livelihoods, land degradation within mining communities in Sierra Leone has also brought significant reductions in ecosystem services such as water supply, as rivers and streams are continually being polluted, posing dire human health issues.

In the Moyamba and Pujehun districts of southern Sierra Leone, the reduction in community farmlands has been further exacerbated by multinational agricultural companies that have acquired vast tracts of land for their crop cultivation. The dispossession of arable lands from community farmers by multinational companies, and the subsequent deterioration of vital ecosystem services in mining communities, without sustainable alternatives or compensation, has sowed a seed of dissatisfaction among affected communities. This has resulted in violent conflicts between the communities and companies. In January 2019, clashes between local communities seeking redress and security personnel protecting company interests resulted in two fatalities and over 2,500 people displaced in Pujehun. This was preceded by the 2018 strike actions in Moyamba that were met by heavy handed responses from security personnel.

To mitigate these land-based conflicts, a project entitled "Mitigating Localized Resource-based Conflicts and Increasing Community Resilience" was launched in December 2019 by the United Nations Development Programme (UNDP), World Food Programme (WFP), and Government of Sierra Leone (GoSL) to formulate policy frameworks and dialogue platforms that will enhance inclusivity, especially of women and youths, in land negotiations, ensuring compliances to cooperate social responsibilities, and development of alternative livelihoods.

As a first step to achieving the goal of this project, the Sierra Leone Agricultural Research Institute (SLARI) was contracted to conduct a detailed Land Degradation Assessment (LDA) of four chiefdoms (Lower Banta and Upper Banta in Moyamba, and Malen and Makpele in Pujehun) to provide data on the availability and quality of land for local farming populations. These data would inform policy options for mitigating localized resource-based conflicts.

In the conduct of this assessment, a synergistic approach, involving both socio-economic and biophysical data, was adopted. The goal is to solicit indigenous perceptions of the impacts of mining and agricultural companies on local livelihoods and environmental quality, and have these perceptions validated by empirical evidence based on established scientific procedures.

The socio-economic surveys targeted household respondents, key informants drawn from stakeholders, and employees of companies. Additionally, focus group discussions were conducted to acquire more diverse perceptions of the subject under study in the target areas. Responses obtained from the socio-economic survey were analysed both qualitatively and quantitatively using descriptive and inferential statistics to arrive at data-driven conclusions. The biophysical survey involved the collection of soil and water samples across the study areas. These samples were analysed for physico-chemical attributes that could be indicative of land degradation. Additionally, the status of land-cover was analysed at two time points (2000 and 2020) using satellite imagery to arrive at indications of land degradation over time.

Indigenous perceptions suggest that the land tenure systems are highly monopolized by local authorities and compensations, or surface rents are grossly inadequate to provide sustainable and alternative livelihoods after land dispossession. The attendant surplus labour, poverty and food insecurity have been major triggers of dissatisfaction and conflict in these communities.

Significant land degradation has been reported based on indigenous perceptions in the four chiefdoms. This is supported by empirical evidence obtained from both the physico-chemical analysis of soil and water samples, and land-cover change over a twenty-year period. There is also a growing unavailability of arable land due to the expanding mining and agricultural land concessions of companies. This is particularly serious in Malen where over half of the arable land has been acquired by Socfin, which holds large concessions of oil palm plantation. Thus, livelihoods from farming, logging, and hunting have been significantly eroded in these areas.

In general, there is observed a growing dissatisfaction among host communities of mining and agricultural companies. From lack of access to land information and participation in land legislation to marginalization in land deals, land deprivation, poor employment opportunities for indigenes, poor healthcare and social amenities, and an increase in social problems, the activities of companies in these communities have largely been regarded as unprofitable to indigenes. In view of the potential for the resurgence of land-based violent conflicts in these communities, greater inclusivity in land negotiations and review of unfavourable transactions, and the fulfilment of corporate environmental and social responsibilities, are recommended.

Acknowledgement

In the conduct of the Land Degradation Assessment (LDA) and production of the final report, several institutions and persons played vital roles and therefore deserve to be acknowledged.

First and foremost, gratitude is expressed to the United Nations Peace Building Fund (UNPBF), the United Nations Development Programme (UNDP), and the World Food Programme (WFP) for providing the funds used in the implementation of this project activity. The contributions of project team members from UNDP and WFP are very much appreciated. Gratitude is further expressed to the Government of Sierra Leone, through the Office of the Vice President, for providing the much needed partnership and coordination of this project.

Thanks and appreciation is expressed to council, management and staff of the Sierra Leone Agricultural Research Institute (SLARI) who provided the required administrative leadership and internal coordination of activities from the inception phase through field data collection to data compilation, data analysis, data verification, report writing, and validation workshop.

This work would not have been successful without the sacrifices of core SLARI scientists who traversed the various communities and ecosystems in the selected study areas to collect socio-economic and biophysical datasets. The works of Dr. Joseph Bandabla, Mr. Akiwande Boyle-Renner, Ms. Matilda Swarray, Mr. Foday Suma, and Mr. Christen Charley are highly recognised; to the technicians, in the Agro-chemistry Lab of the Njala Agricultural Research Centre (NARC) of SLARI, for their contributions in sample processing and analysis. Thanks are also expressed to the enumerators who administered the questionnaires and assisted in the data compilation. To the tour guides, drawn from local communities, who assisted the survey teams in navigating through the study areas and also in the collection of soil auger samples.

Finally, the invaluable contributions of our eminent respondents in household interviews, key informant interviews, employee interviews and focus group discussions are well appreciated. Special thanks go to local authorities including paramount chiefs, women and youth leaders, and government officials of the Moyamba District Council, Pujehun District Council and the District Security Coordinator in the Office of National Security (ONS) in Pujehun District, for providing the necessary guidance and support during the field work. The contributions of local Non-Governmental Organisations (NGOs) like Fambul Tok International in providing an independent view of the prevailing situation, and the support of Socfin and Natural Habitat for granting the data collectors audience during work hours, are worthy of acknowledgement.

CHAPTER ONE

1.0 Introduction

1.1 Background

Land degradation is a major concern facing the global economy due to its implications for agriculture, environment, and human health (Taddese 2001; Pan and Li 2010; Masoudi and Amiri 2015; Masoudi 2018). The United Nations Convention to Combat Desertification (UNCCD) is the international policy framework that addresses land degradation. According to UNCCD, land degradation is "any reduction or loss in the biological or economic productive capacity of the land resource base. It is generally caused by human activities, exacerbated by natural processes, and often magnified by and closely intertwined with climate change and biodiversity loss". Land degradation involves the loss of the productive capacity of land as manifested in reduced soil fertility, and other natural resources (FAO 2002). Specifically, it is a long term loss of ecosystem function and productivity due to disturbances from which degraded land cannot recover without intervention (Bai et al. 2008).

Land degradation has a multitude of manifestations, depending on the type of the underlying driver and the environment in which degradation occurs. It could lead to reductions in flora and fauna, accelerated deterioration of soil physico-chemical properties, substantial decline in ecosystem services, and increased hazards to human occupancy (Ponce-Hernandez 2002). Studies have shown that land degradation impacts both the social and environmental fabrics of human civilizations (Taddese 2001). By the start of the 21st century, over 2.6 billion people had already been affected by land degradation in more than one hundred countries (Adams and Eswaran 2000). Assessing the rate and extent of land degradation and its attendant impacts on the man-environment system therefore remains pivotal in formulating appropriate response strategies that would ensure the most efficient use of land resources while incurring minimal environmental costs. This resonates with the Sustainable Development Goal (SDG) 15.3 "Life on Land" which by 2030 aims to combat desertification, and restore degraded land and land affected by desertification, drought and floods, and strive to achieve a degradation-neutral world (United Nations 2015). In a changing climate, adequate mechanisms that allow for the efficient management of the biological systems that underpin the global economy are essential. This would be especially relevant for vulnerable countries like Sierra Leone in reducing their exposure to land degradation impacts and improving their adaptive capacity.

As a country endowed with huge reserves of minerals, mining is one of the most notable causes of land degradation in Sierra Leone. With agriculture accounting for at least 52% of the Gross Domestic Product (GDP) of Sierra Leone, the degradation of arable lands by an ever expanding mining sector has affected not only the country's export capital but also food security, especially at the rural household level. The share of land for community farming has reduced significantly as mined-out lands are no longer arable, and spill over pollution effects to adjacent non-mining communities could also render their lands infertile and unproductive. Community farmland deprivation as a result of mining is further exacerbated by multinational agricultural companies that acquire huge land concessions. This could be a recipe for chaos in a onetime war-torn country that is still battling to consolidate peace, amidst extreme poverty, youth unemployment, gender inequality, and wide spread corruption. The potential for the emergence of land-based conflicts in affected communities has been manifested in standoffs between locals and companies in Moyamba and Pujehun districts in southern Sierra Leone.

Against this backdrop, the United Nations Development Program (UNDP) together with the World Food Program (WFP) and the Government of Sierra Leone (GoSL) launched, on 3rd December 2019, a project entitled "Mitigating Localized Resource-based Conflicts and Increasing Community Resilience" to be piloted in selected chiefdoms of Moyamba and Pujehun. The project, funded by the United Nations Secretary General's Peace Building Fund (PBF), aims at mitigating local conflicts and increasing community resilience by improving regulatory environment and inclusive investment, instituting dialogues platforms, supporting communities to develop alternative livelihoods, and building the capacity of government and private institutions to be more accountable and responsive to the needs of the local people.

To this end, the Lower Banta and Upper Banta chiefdoms in the Moyamba District and the Malen and Makpele chiefdoms in the Pujehun District have been selected as these localities have, in recent times, been more prone to violent conflicts and social unrest due mainly to the deteriorating relationships between local communities and multinational companies investing in large-scale mining and farming. Using a Community-Based Participatory Planning (CBPP) approach through agricultural livelihood development, this project is envisaged to benefit some 2,500 women and youths in the targeted communities. In rolling out this programme, however, data on land ownership and land degradation are a fundamental prerequisite as they would inform relevant policy frameworks and dialogue platforms that would ensure an equitable distribution of land resource gains. Hence a detailed Land Degradation Assessment (LDA) has been conducted in the aforementioned project locations in Moyamba and Pujehun.

1.2 Statement of Problem

Land degradation is evident in both developed and developing countries (Bai et al. 2008), but its magnitude and severity are more prominent in low-income countries (Teklu 2014). Africa is the region most vulnerable to, and perhaps the most widely affected by, land degradation (Thiombiano and Tourino-Soto 2007; Nkonya et al. 2016), and this is not unconnected to extractive industries being the major livelihoods. Kirui and Mirzabaev (2015) estimated land degradation to have affected about 51%, 41%, 23% and 22% of the land area of Tanzania, Malawi, Ethiopia and Kenya, respectively, and associated costs to GDP were estimated at 14% for Tanzania, 7% for Malawi, 23% for Ethiopia and 5% for Kenya. Despite the recorded severity of land degradation in the African continent, the conditions seem to be getting worse, and left unabated, this would lead to the continued loss of vital ecosystem services such as agricultural production, biodiversity, and water conservation. Nkonya et al. (2016) warned that if appropriate mitigation measures are not taken, by 2030, soil erosion and denudation in Africa may lead to a total loss of nitrogen, phosphorus and potassium (NPK) soil nutrients in the neighbourhood of 4.74 tons/year, worth approximately USD 72.4 billion of purchasing power parity (PPP) in present value, which is equivalent to USD 5.1 billion PPP per annum.

In view of the above, there is an urgent need to halt, or reverse, the spate of land degradation in Africa. Several international instruments have been developed in this regard, including the Rio+20 zero net land degradation target by UNCCD, which aimed at reducing degradation and promoting the restoration of degraded lands (Gessesse et al 2015). In implementing these international frameworks, credible and spatially explicit land degradation data are required (stavi and Lal 2015) as they are a vital prerequisite for the implementation of land resource rehabilitation policies (Winslow et al. 2011). However, areas most prone to land degradation are data-poor, with data being obtained mainly from gross estimates (Tully et al. 2015). In Sierra Leone, land degradation assessments have been mostly focused on urban environments with emphasis on land-cover (Mansaray, Huang and Kamara 2016; Gbanie et al. 2018). Little research efforts have been devoted to understanding the dynamics of land degradation, due to mining, on rural livelihoods, despite their potential implications for localized conflicts. In the rural areas of Moyamba and Pujehun, mining activities have been associated with significant reductions in arable lands. Compensations offered to landowners have largely been regarded unsustainable, and this could be a recipe for land-based disputes in the affected communities. Thus, the acquisition of land degradation data to inform policies on sustainable land use and alternative livelihoods in rural Sierra Leone is more desirable at the present than ever before.

The Moyamba and Pujehun districts of southern Sierra Leone are not only home to some of the country's mineral resources but also host vast expanses of arable lands. The activities of multinational mining and agricultural companies in these areas trigger significant changes in land-use, thereby making these districts prone to land deprivation and/or land degradation. The Socfin Agricultural Company, a subsidiary of the Belgian Corporation (SOCFIN), and Natural Habitats, a Dutch company, have together acquired 49,173 hectares (ha) of land in the Malen and Makpele chiefdoms in Pujehun District, dedicated to oil palm plantations. In Moyamba District, the Australian owned Sierra Rutile Company, the world's second largest miner of titanium ore, has a concessionary license covering over 56,000 ha across the three chiefdoms of Bagruwa, Lower Banta and Upper Banta. Additionally, the Romanian bauxite mining company Vimetco operates an aluminium ore mining licence that covers an extent of 32,100 ha. It is no doubt that rutile and bauxite mining activities in these communities could pose tremendous environmental hazards to areas both within and proximal to such operations (Olsgard and Hasle 1993; Abdullah et al. 2016). Such hazards include the contamination of water bodies, depletion of soil nutrients, flooding of adjacent lowlands, and soil erosion. This has the tendency to substantially decrease cultivable land and increase yield gaps in a mostly subsistence and smallholder farming system that was already characterized by low yields.

With agriculture being the mainstay of most households in Moyamba and Pujehun, land acquisition by multinational companies, with no alternative livelihoods to the inhabitants, intensifies food insecurity, unemployment and poverty. Although there is no systematic or direct causality between environmental degradation and the incidence of conflicts (Bernauer, Böhmelt and Koubi 2012), the effect of land degradation on conflict seems to be dependent on several intervening socio-economic factors that determine adaptive capacity (Kahl 2008; Salehyan 2008; Buhaug, Gleditsch and Theisen 2010). Due to the lack of, or at least ineffective, dialogue platforms on land acquisition and land compensation in the operational areas of multinational mining and agricultural companies in Moyamba and Pujehun districts, communities are increasingly resorting to violence as a means of expressing their discontent and seeking redress. The formulation of policy actions for mitigating land-based conflicts in these communities would however rely on more spatially explicit information on the extent of land degradation and its attendant impacts on local populations. Thus for land acquisition and land-use processes to be more inclusive and aligned with national policy frameworks, a detailed land degradation assessment, in target project locations, to provide an overview of the impacts of extractive industries on the availability and quality of arable land, is essential.

1.3 Project Objectives

Both mining and large-scale agricultural investments have been linked to a number of socio-economic and environmental issues in host communities of such investments. From the loss of farmlands and indigenous livelihoods to deforestation, nutrient depletion and pollution, the mining and agriculture sectors have presented significant challenges to the fight against rural poverty, hunger and environmental degradation in developing countries like Sierra Leone. Consequently, social tensions have emerged in affected communities as recorded in recent conflicts between companies and indigenes in the Moyamba and Pujehun districts of southern Sierra Leone. Left unresolved, these resource-based tensions have the tendency to undermine national security in a onetime war-ravaged country that is still battling to consolidate peace.

To formulate informed policies and sustainable strategies that would improve community resilience to land degradation, a detailed land degradation assessment has been conducted in target chiefdoms of the Moyamba and Pujehun districts. Through a consultative process with local communities and key stakeholders, the assessment included the following objectives:

- Determine the area and impact of land degradation within the concessionary areas of companies (Sierra Rutile, Vimetco, Socfin, and Natural Habitat) in target chiefdoms.
- Conduct assessment focusing on the impact of extractive industries (mining, farming, and logging) on the availability and quality of arable land for community farmers.
- Produce a land degradation assessment report substantiated with relevant evidences, indicating the type of land degradation (deforestation, nutrient depletion, pollution of soil and water bodies) and the distribution of affected communities and their extents.
- Provide a comparative analysis between the land degradation assessment findings and the Environmental, Social and Health Impact Assessment (ESHIA) reports of mining and multinational agricultural companies in view of national regulatory frameworks.

Data obtained from this study would inform policy makers and stakeholders on the dynamics of land degradation and land acquisition in view of the activities of multinational mining and agricultural companies in the target chiefdoms. These data would direct a dialogue platform, between communities and companies, on which types of agricultural livelihood activities are most suitable in addition to guiding the alignment of policy frameworks on land tenure and sustainable land-use. This would ultimately contribute to achieving the United Nations Peace Building Fund (PBF) project’s overall aim of “*Mitigating localized resource-based conflicts and increasing community resilience in the Moyamba and Pujehun districts of Sierra Leone*”.

CHAPTER TWO

2.0 Materials and Methods

This chapter presents the methodology employed in addressing the LDA project objectives.

2.1 Socio-Economic Data Collection

2.1.1 Study Area

This study was conducted in the Lower Banta and Upper Banta chiefdoms of Moyamba District and the Malen and Makpele chiefdoms of Pujehun District in southern Sierra Leone. Figure 1 shows the location of study areas, and the spatial distribution of data collection sites.

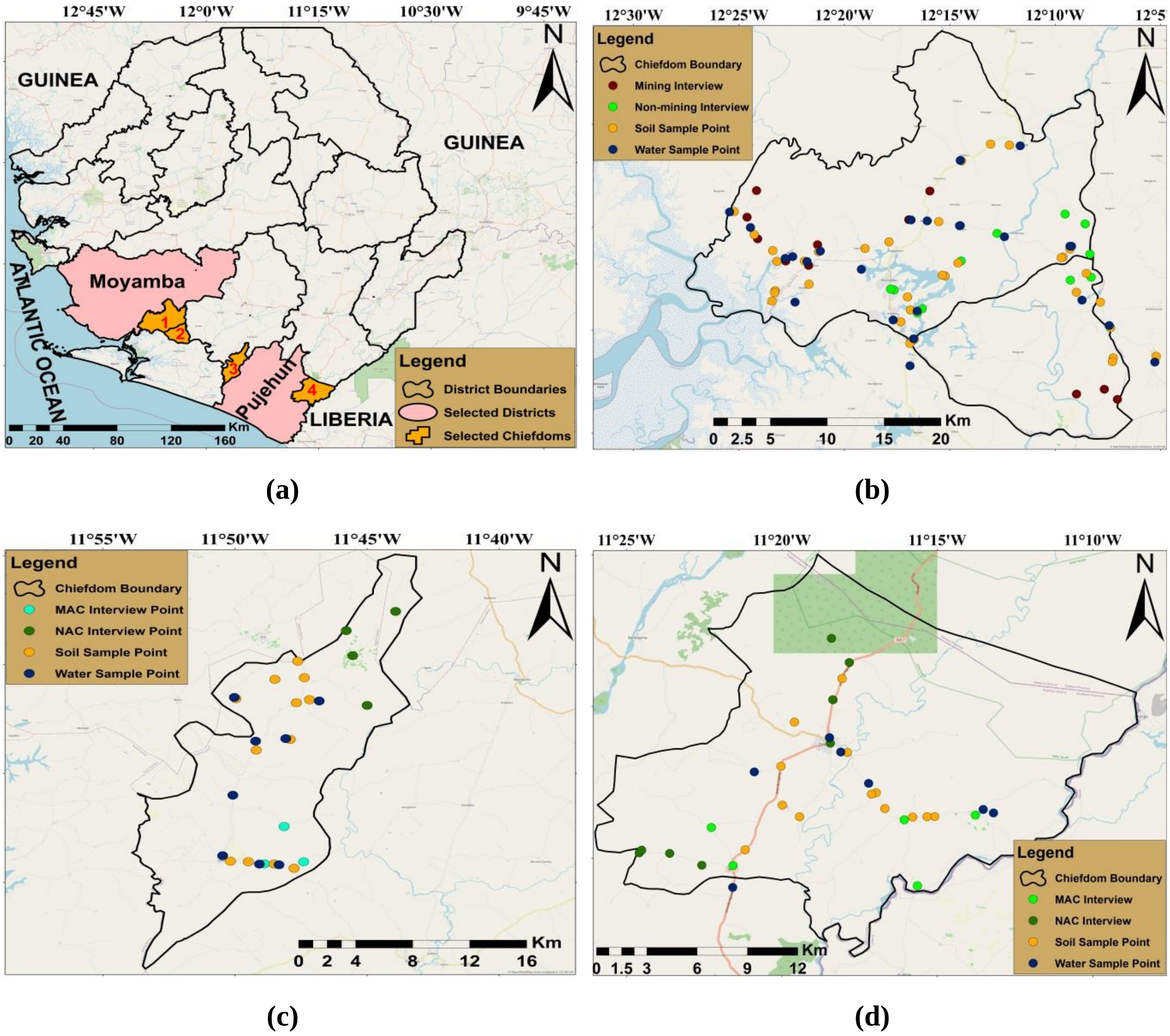


Figure 1 Location maps; (a) location of chiefdoms, where 1, 2, 3, and 4 indicate Lower Banta, Upper Banta, Malen and Makpele, respectively, (b) distribution of survey points in Lower Banta and Upper Banta, (c) distribution of survey points in Malen, and (d) distribution of survey points in Makpele.

Sierra Leone is located in West Africa along the Atlantic coast. The country typically falls within the tropical rainforest and Guinea savanna ecosystems. Two seasons are generally observed in Sierra Leone; the rainy season (April to October) and the dry season (November to March), and each is characterized by the dominance of a particular type of air-mass blowing over the country temporarily, brought by relative shits of the Inter-Tropical Discontinuity (ITD). From shapefiles of the ArcGIS online resources, Sierra Leone is about 72,722 km^2 in area (72,722,000 hectares) and nearly three-quarters of the land is suitable for crop cultivation. Of this land area, 4.3 million hectares are uplands with low soil fertility and an estimated 1.06 million hectares are fertile lowlands with a considerable potential for crop cultivation. However, less than 15% of this arable land is under cultivation. From the 2015 census report, Sierra Leone has a total population of 7,075,641 (Statistics Sierra Leone 2015).

Moyamba District is approximately 6,978 km^2 in area and has a population of about 381,588 (Statistics Sierra Leone 2015), half of which falls within the active workforce (age between 15 and 64). There are about 61,880 households in Moyamba, 84.5% of which are agricultural households, thereby making agriculture the mainstay of the inhabitants of Moyamba District (Statistics Sierra Leone 2015). Of the total number of agricultural households, 72.2% are headed by males. The major agricultural crops grown in Moyamba District include tree crops (cashew, oil palm and cacao), cereals (rice, maize, millet and sorghum), tubers (cassava, yam and sweet potato), horticultural crops (black pepper, ginger and pineapple), and sugarcane. Farming in Moyamba is mostly at smallholder commercialization and subsistence scales, despite the vast land and water resources in the district. Small-scale livestock rearing is also widely practiced and artisanal fishing is more common among the coastal communities of the district. Additionally, rutile and bauxite mining are carried out by Sierra Rutile and Vimetco.

Pujehun District is approximately 3,900 km^2 in area, and has a population of about 346,461, 49% of which falls between age 15 and 64. Pujehun District has a total of 51,514 households, 77.1% of which depend on agriculture. About 72.1% of the farming households are headed by males (Statistics Sierra Leone 2015). The main crops grown in Pujehun include cassava, sweet potato, coffee, cocoa and oil palm. Similar to Moyamba, farming in Pujehun is mostly at smallholder commercialization and subsistence scales. Diamond mining is a key livelihood source in Pujehun and artisanal fishing is also practiced along the coastal areas of the district.

Based on the above narrative, it is apparent that there exist several competing land uses in Moyamba and Pujehun, which have implications on environment and local livelihoods. For the assessment of land degradation in the above districts, four chiefdoms have been selected; Lower Banta (about 505 km^2 in area) and Upper Banta (about 183 km^2 in area) chiefdoms in Moyamba, and the Malen (about 276 km^2 in area) and Makpele (about 418 km^2 in area) chiefdoms in Pujehun. Lower Banta, Upper Banta, Malen and Makpele have populations estimated at 37,275; 10,513; 49,197 and 31,181, respectively (Statistics Sierra Leone 2015).

2.1.2 Research Design

A participatory approach was employed to solicit indigenous perceptions on the impacts of mining and agricultural companies on local livelihoods and the environment. Given the inherent heterogeneity amongst potential respondents, a Mixed Method Research Design (MMRD) was employed (Wisdom & Creswell 2013). This approach combines a wide range of qualitative and quantitative data collection techniques and tools to meet a global objective in a multi-stakeholder environment and hence more holistic and detailed information was obtained. Three socio-economic data collection tools were used: structured questionnaire for household respondents; semi-structured questionnaire for interviews with key informants and company employees, and Focus Group Discussions (FGDs) for wider community opinions.

2.1.3 Sampling Procedures

The sampling scheme designed and implemented in this study was economical, easy to use and also provided unbiased estimates with little variance. The sampling frame consisted of household heads, stakeholders, and company employees. The study employed a multi-stage sampling approach that utilises both probability and non-probability sampling techniques.

2.1.3.1 Determination of sample size

The sample sizes for the socio-economic surveys were determined using Equation 1.

$$n = \frac{z^2pq}{d^2} \qquad 1$$

where n = the sample size, z =1.96 (96% confidence level), p = proportion of population (the proportion of household negatively impacted by land degradation), q = a weighting variable computed as 1-p, and d =±5% is the error margin. For maximum sample size p=0.5 was used.

$$n = \frac{1.96^2\text{x}0.5\text{x}0.5}{0.05^2} = \frac{0.9604}{0.0025} = 384.16 \approx 400$$

However, in an attempt to increase data precision, the sample size was increased to 500.

2.1.3.2 Sample size allocation

The study was conducted in four chiefdoms that were purposively selected by UNDP and partners in view of the perceived impacts of land degradation or dispossession in those areas. The sample frame of the households was the total number of households in those chiefdoms. Table 1 presents the distribution of respondents to the survey categories used in this study.

Table 1 Distribution of targeted and accomplished survey categories across the four chiefdoms.

Category	Targeted persons/groups	Accomplished
Household Interviews	502	499
Key Informant Interviews (KIIs)	130	132
Employee/Company Interviews (ECIs)	40	20
Focus Group Discussions (FGDs)	24	24

Source*: LDA Field Survey Data, 2020*

The sample sizes were allocated based on the allocation proportional to size method. In each chiefdom, the sample size was divided equally into mining and non-mining communities, as well as multinational agricultural communities (MACs) and non-MACs. For time efficiency while ensuring representativeness, the sample size of each household was no greater than 10 and no less than 5. Communities with and without land degradation activities were selected by simple random sampling and finally the households were randomly selected from these localities. Table 2 presents the distribution of household respondents relative to population.

Table 2 Distribution of household respondents across the selected chiefdoms.

District	Chiefdom	Total households	Households to sample size	Households in land degradation localities to sample size	Households in non-land degradation localities to sample size	No. of localities with land degradation activities	No. of localities without land degradation
Moyamba	Lower Banta	7,649	211	106	106	11	11
	Upper Banta	2,199	61	30	30	3	3
Pujehun	Makpele	5,102	141	70	70	7	7
	Malen	3,159	87	45	45	5	5
Total		18,109	500	251	251	26	26

Source: *LDA Field Survey Data, 2020*

2.1.3.3 Key informant interviews (KIIs)

A total of 132 key informants drawn from community stakeholders and government officials and 20 employee interviews were completed under this category. Initially, 40 respondents were targeted for the employee interviews, with 10 per company. This was however not accomplished as interviews were not granted for employees of Sierra Rutile and Vimetco due to COVID-19 restrictions. The selected candidates for the key informant interviews were:

i. The chief/headman, women's leader and youth leader in each of the communities.
ii. The Paramount Chief or his/her representative (speaker) in each chiefdom.
iii. Three senior employees from each company (Socfin and Natural Habitat).
iv. Senior government officials including Moyamba District Council (MDC), Ministry of Agriculture and Forestry (MAF), Office of National Security (ONS) in Pujehun, and land advocacy and land rights organizations like Fambul Tok International.

2.1.3.4 Focus group discussions (FGDs)

Three categories of FGDs including adult males, adult females, and youths, were conducted across communities of mining, non-mining, MACs and non-MACs. Two FGDs for each respondent category were conducted for each community type, totaling 24 FGDs (Table 1).

2.1.4 Data Collection

FGDs, KIIs, ECIs and household interviews were conducted to acquire socio-economic data, based on indigenous perceptions, on the causes and attendant impacts of land degradation. Respondents included household heads, community stakeholders, and company employees.

Primary data involved both qualitative and quantitative data and were collected through field interviews. Tools for qualitative data collection were participant observations, FGD and KII (community authorities, private companies, administrative, and agricultural field officers). For quantitative data collection, structured questionnaires with both closed and open-ended questions were employed for interviews within the households. Secondary data were also sourced from scientific reports, maps and statistical abstracts (Saunders et al. 2011). All these information sources were harmonized to provide a detailed assessment of the perceptions of the impacts of mining and agricultural companies on the environment and local livelihoods.

Data from households, KIIs and ECIs were captured electronically with the aid of tablets. On the other hand, data from FDGs were captured either in writing or by audio/video recordings.

2.1.4.1 Focus group discussions

Open discussions were conducted on issues surrounding land degradation, in the surveyed communities, attributable to the activities of mining and agricultural companies. During the process, discussions were done with the three different survey groups in mining communities, non-mining communities, agricultural communities and non-agricultural communities across chiefdoms. Categories of discussions were adult males (men above 35 years), adult females (women above 35 years) and youths (comprising males and females within the ages of 18 and 35). Figure 2 provides some of the photos taken during FGDs in the targeted communities.

(a)

(b)

(c)

(d)

Figure 2 FGDs across age and gender groups in the study areas; (a) introduction of the project theme, (b) FGD with adult males, (c) FGD with adult females, and (d) FGD with male and female youths.

2.1.4.2 Key informant interviews

Key informants were interviewed using a semi-structured questionnaire to assess key issues discussed on the household questionnaire with few specific questions. Figure 3 provides some of the photos obtained during key informant interviews across the selected chiefdoms.

(a) (b)

Figure 3 Selected KIIs; (a) the Paramount Chief of Makpele Chiefdom, and (b) a government official.

2.1.4.3 Employee interviews

Employees from mining and multinational agricultural companies were interviewed to solicit their perceptions of the impacts of companies on land-use, environment and local livelihoods. Figure 4 provides some of the photos taken during employee interviews in the study areas.

(a) (b)

Figure 4 Selected employee interviews with; (a) an international staff, and (b) a local staff.

2.1.4.4 Household interviews

The individual/household interviews were conducted with a Samsung galaxy tab (android devices) programmed with the Census and Survey Processing System (CSPro 6.3) software through a process called electronic data capture. This survey targeted household heads or their representatives and some of the photos taken during this exercise are provided in Fig. 5.

(a) (b) (c) (d)

Figure 5 Selected household interviews with (a) a youth household head and an elderly male, (b) a female household head, (c) a male household head, and (d) female (dependant) household members.

2.1.5 Data Analysis and Presentation

Qualitative data were analysed using non-statistical methods and these involved extracting and clustering information into themes and sub-themes and ranking per priorities, weights or proportional responses to explain the impacts of extractive industries on local livelihoods. Qualitative data were employed to validate and complement quantitative data (Bryman 2012).

Quantitative data obtained from individual interviews were exported from CSPro to various statistical packages such as Statistical Analysis Systems (SAS 9.3), Microsoft Excel 2010 and STATA version 14 for analysis using different analytical tools. Descriptive and inferential statistics were employed to aid the analysis. Pair-wise ranking was performed to help identify the most perceived problems caused by mining and agricultural companies in the study areas, and to rank socio-economic activities based upon their contributions to household livelihood. Frequencies, percentages and means were employed in the discussion of the results obtained. Cross tabulations involving chi-square tests were also utilised to test statistical differences in various variables between mining and non-mining communities and MACs and non-MACs.

2.2 Biophysical Data Collection

2.2.1 Soil Physico-chemical Data

A total of 82 composite soil samples were collected across the four chiefdoms, and sample distribution was proportionate to chiefdom land area. This resulted in 30 samples in Lower Banta, 11 samples in Upper Banta, 16 samples in Malen, and 25 samples in Makpele. Sample points were spatially distributed (Fig. 1) to account for differences in terrain and the land-cover classes of interest across the chiefdoms. It is important to note that in Fig. 1 some soil sample points overlap with the socio-economic survey points. At each soil sample point, a 100 m^2 area was mapped and divided equally into four segments, each 50 m^2 in area. Soil auger samples, at the top 20 cm layer, were collected from the midpoint of each segment. Samples from the four segments in each sample point were combined to derive a composite sample that is georeferenced to the GPS coordinate of the centre of the 100 m^2 sample point. Figure 6 shows some photos obtained during the collection of soil samples across chiefdoms.

Collected soil samples were placed in polythene bags and labelled. In the laboratory, samples were air-dried and sieved using two mesh sizes of 2.0 mm and 0.5 mm. The fractions from the same sample were thoroughly mixed followed by quartering several times and discarding the other two quartered fractions before finally stored into plastic bottles awaiting analysis. The processed soil samples were analysed for the potential of hydrogen (pH), electrical conductivity (EC), percentage organic carbon (OC), total nitrogen (tN), total Phosphorus (tP), exchangeable potassium (Exc. K), exchangeable magnesium (Exc. Mg), total iron (tFe), arsenic (As) and cadmium (Cd). These parameters were selected as they provide an indication of not only the status of soil fertility but also the presence of heavy metal contaminants which can be accumulated in both mining and agricultural soils and have dire health consequences.

Figure 6 Soil sample collection at (a) barren land in Lower Banta, (b) a degraded wetland in Upper Banta, (c) an oil palm plantation in Malen, and (d) a prepared land for rice farming in Makpele.

In this study, wet chemical methods (wet chemistry) were employed in the analysis of soil samples. Table 3 presents the methods and instruments used in analysing each soil parameter.

Table 3 Outline of parameters, methods and instruments used in soil sample analysis.

Soil sample parameters	Methods	Instruments/methods
pH (unitless)	1:1 – Soil-Water Mixture	pH Meter
EC (dS/cm)	1:2 – Soil -KCl Mixture	Electrical Conductivity Meter
OC (%)	Colorimetric Method	Spectrophotometer
tN (%)	Kjeldhal Digestion	Kjeltron
tP (mg/kg)	Bray 1 Extraction	Spectrophotometer
Exc. P (mg/kg)	Ammonium Acetate Extraction	Flame Photometer
Exc. Mg (mg/kg)	Ammonium Acetate Extraction	EDTA Titration
tFe (mg/kg)	Ammonium Bicarbonate-DTPA Method	EDTA Titration
As (mg/kg)	Sodium Bicarbonate Extraction	EDTA Titration

Cd (mg/kg)	Hydrofluoric Acid Extraction	EDTA Titration

EDTA = Ethlylenediaminetetraacetic acid; DTPA = diethylenetriaminepentaacetic acid

2.2.2 Water Physico-chemical Data

A total of 41 water samples were collected from rivers, streams, swamps and protected wells across the four chiefdoms. Similar to soil sampling, the distribution of water samples (Fig. 1) was proportionate to chiefdom land area, and this resulted in 15 samples for Lower Banta, 6 samples for Upper Banta, 8 samples for Malen, and 12 samples for Makpele. Similar to soils, some water sampling points intersect with the socio-economic data points. Figure 7 presents some of the photos taken during the collection of water samples across the four chiefdoms.

(a)

(b)

(c)

(d)

Figure 7 Water sample collection; (a) protected well (background water quality) in Lower Banta, (b) polluted stream in Upper Banta, (c), polluted stream in Malen, and (d) polluted stream in Mapkele.

Similar to the soil samples, all water samples were labelled, georeferenced against their GPS coordinates, stored in bottles and transported to the laboratory where they were preserved before physico-chemical analyses. Water samples were analysed for pH, EC, total dissolved solids (TDS), total hardness, nitrates, phosphates, sulphates, tFe, As, Cd and mercury (Hg). Similar to the soil analysis, water samples were analysed using wet chemical methods. Table 4 provides an outline of the methods and instruments used in the analysis of water samples.

Table 4 Outline of parameters and methods/instruments used in water sample analysis.

Water sample parameters	Instruments/methods
pH (unitless)	pH Meter
EC (µS/cm)	Electrical Conductivity Meter
TDS (mg/L)	TDS Meter
Total Hardness (mg/L)	EDTA Titration
Nitrates (mg/L)	Kjeltron
Phosphates (mg/L)	Spectrophotometer
Sulphates (mg/L)	EDTA Titration
tFe (mg/L)	EDTA Titration
As (µg/L)	EDTA Titration
Cd (µg/L)	EDTA Titration
Hg (µg/L)	Spectrophotometer

EC = Electrical Conductivity; TDS = Total Dissolved Solids

2.2.3. Land-cover Data

In the assessment of land degradation, data was collected on land-use/land-cover (LULC) change. The Inter-Agency and Expert Group on the Sustainable Development Goals (IAEG-SDGs) has agreed that SDG 15.3 can be evaluated by summing up land-cover change, land productivity, and carbon stocks below and above ground. These three indicators of SDG 15.3 underline the importance of land-cover in the monitoring and assessment of land degradation (Dubovyk 2017). Changes in LULC have been linked to soil erosion, flooding, drought, and ultimately reduced land productivity or land degradation (Firdaus et al. 2014). In the current study, LULC data have provided information on the spatial distribution of vegetation, water bodies, bare land, and man-made features, which can be related to variations in soil physico-chemical properties and hence soil fertility (Majule 2003) and water quality. In this study, a first level land-cover classification scheme (Anderson 1976) was adopted to map changes in land-cover, which could reveal proximate causes of land degradation. The broad land-cover classification scheme include natural forest cover, oil palm plantation, crop/fallow land, inland valley swamp, mangrove swamp, open water body, and built-up/barren land. Figure 8 presents photos of the land-cover categories of interest obtained during field investigation.

(a) **(b)**

(c) **(d)**

(e) **(f)**

(g)

(h)

Figure 8 Investigated land-cover; (a) natural forest cover, (b) oil palm plantation, (c) crop land, (d) fallow land, (e) inland valley swamp, (f) mangrove swamp, (g) open water, and (h) built-up/barren.

The land-cover categories associated with soil and water samples, and in the proximity of socio-economic data sampling locations, were recorded to provide training and validation samples for land-cover mapping. From this approach, a total of 300 land-cover data points were obtained around socio-economic and biophysical data collection locations. Thus the distribution of land-cover data points is also proportionate to chiefdom land area. Table 5 shows the allocation of land-cover, soil and water sampling points across the four chiefdoms.

Table 5 Distribution of land-cover, soil and water sample points across the four chiefdoms.

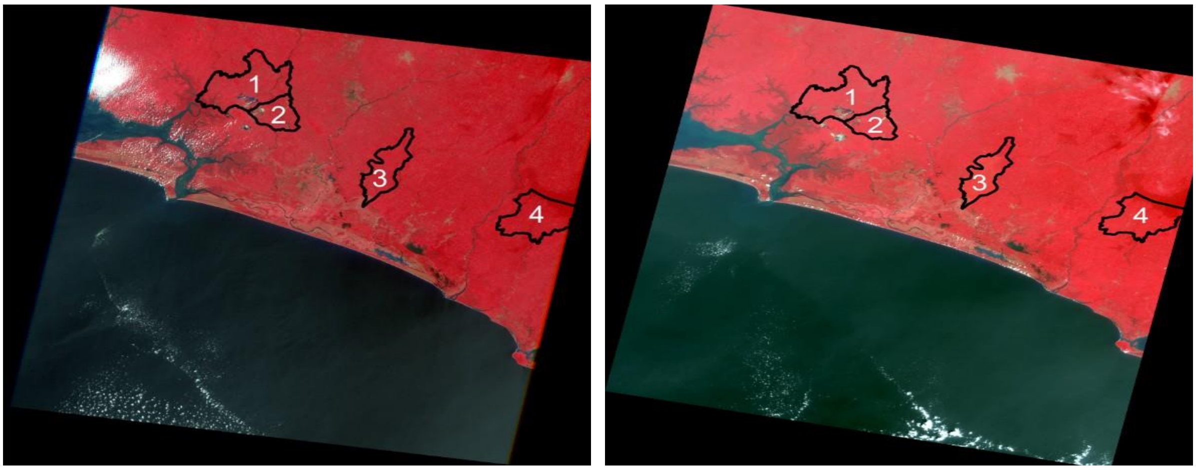
Category	Built/barren	Wetland	Cropland	Fallow	Trees/forest	Soil	Water
Lower Banta	26	18	26	22	18	30	15
Upper Banta	9	7	9	8	7	11	6
Malen	21	15	21	18	15	16	8
Makpele	14	10	14	12	10	25	12
Total	70	50	70	60	50	82	41

Source*: LDA Field Survey Data, 2020*

For each land-cover class, GPS points were divided into training and validation datasets for the 2020 image classification and accuracy assessment (Hay 1988), respectively. The points were overlain on satellite imagery and further maximised by drawing a polygon around each, thus resulting in thousands of pixels for each land-cover. Due to the lack of a corresponding field survey for the satellite images obtained at 2000, training samples were obtained from visual image interpretation based on expert knowledge (Mansaray, Huang and Kamara 2016).

2.2.4. Satellite Data Collection and Processing

For the purpose of land-cover mapping and change detection in the current LDA project, optical satellite images from the Landsat archive were collected from the earthexplorer website (https://earthexplorer.usgs.gov) of the United States Geological Survey (USGS). Since its first launched in 1972 with the Multispectral Scanner (MSS), the Landsat satellite series has provided the longest continuous archive of earth observation data for civilian applications, and its data have been the most widely used in land-cover investigations. Land-cover mapping and change detection analysis was conducted over a 20-year period at two time points (2000 and 2020). For the initial time point (2000), Landsat-7 Enhanced Thematic Mapper plus (ETM+) images were acquired whereas for the final time point (2020), Landsat-8 Operational Land Imager (OLI) images were obtained. Satellite images were acquired at near-anniversary dates to minimise differences in spectral responses between different times of the year. Two Landsat footprints were required to provide a complete coverage of all four chiefdoms. As a result, images were acquired on 7th and 12th February 2000, and on 1st and 10th January 2020. The months of January and February were selected as they fall within the mid dry season in Sierra Leone during which cloud-free satellite images are abundant. The period from 2000 to 2020 represents the post-war era which is generally characterized by an intensification of primary economic activities (agriculture, logging, and mining). Landsat images with less than 10% cloud cover were acquired. All images were processed for the correction of atmospheric effects based on the Fast Line-of-Sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) module available in the Environment for Visualizing Images (ENVI) 5.1 software (Cooley et al. 2002). For each Landsat scene, the six reflective bands; blue, green, red, near infrared (NIR), short wave infrared (SWIR) 1 and 2, were subset and clipped to the areal extents of Lower Banta, Upper Banta, Malen and Makpele, respectively. Figure 9 shows an overlay of chiefdom boundaries on the satellite images at 2000 and 2020.



(a) **(b)**

Figure 9 Landsat images in False Colour Composite (FCC432) over the selected chiefdoms (shown in polygon outlines); (a) Landsat-7 ETM+ at 2000, and (b) Landsat-8 OLI at 2020, where 1, 2, 3 and 4 indicate the Lower Banta, Upper Banta, Malen and Makpele chiefdoms, respectively.

2.3. Land Degradation Assessment

Various methodologies and combinations of indicators have been employed to assess land degradation. However, there is no universal agreement among the scientific community for the assessment of land degradation (Masoudi, Joker and Pradham 2018) as existing global assessment tools of land degradation differ in the selection of indicators, spatial scale, and data quality (Le, Nkonya and Mirzabaev 2016; Safriel 2017). Generally, three aspects of land degradation can be assessed (FAO-UNEP 1984); current status, rate or trend, and risk or vulnerability of hazard. Among these three categories of land degradation assessment, more emphasis has been placed on the ‘current status’ (Masoudi, Joker and Pradham 2018) due to the lack of historical information especially in data-poor countries like Sierra Leone. In this study, soil and water samples were analysed to provide the ‘current status’ while also revealing potential risks or vulnerability to hazard based on comparison of physico-chemical attributes with environmentally acceptable or agriculturally tolerable limits. Additionally, land-cover change was computed to provide not only the ‘current status’ but also the rate or trend and risk or vulnerability to hazard. Land-cover maps were obtained from Landsat images using the support vector machine (SVM) classification algorithm (Vapnik 1998) available in the ENVI 5.1 software. SVM has been widely applied in land-cover mapping with success (Mansaray et al. 2019). Land-cover mapping and change detection provides a spatially explicit understating, with empirical evidence, of the drivers and impacts of land degradation, and this would inform policies on land-use planning and alternative livelihoods.

2.4 Comparative Analysis

The activities of primary economic sectors, especially mining and large-scale farming, are some of the most commonly linked to land degradation, more so in developing countries like Sierra Leone where they account for the largest contributions to Gross Domestic Product (GDP). In an era of growing demands for environmental sustainability, measures that ensure the most efficient use of natural resources while incurring minimal, if not zero, environmental costs are highly desirable. It is against such a backdrop that prior to the establishment of mining and agricultural companies in Sierra Leone, an Environmental, Social and Health Impact Assessment (ESHIA) is a prerequisite to obtain an operations license (EPASL 2012). This is on the understanding that with the information obtained from an ESHIA, prospective companies can be placed in good stead to respond to, and mitigate, the potential negative impacts of their operations on host communities through the design and implementation of an Environmental, Social and Health Management Plan (ESHMP) by the investment company.

However, ESHIA reports are provided by consultants hired by the companies themselves, which begs the question as to what extent potential negative impacts are underestimated or the impacts of corporate social responsibilities and ESHMPs are overestimated. There is thus the dire need for an independent assessment of the impacts of these companies as provided by the current land degradation assessment of the selected chiefdoms in Moyamba and Pujehun.

In line with international obligations and best practices, several instruments on environment and land resources management have been drafted and implemented in Sierra Leone. Thus for the purpose of the comparative analysis of the LDA Report and relevant company ESHIA reports, literature on national environment and development policies are first reviewed in good detail to lay the foundation for the frame of reference and grounds for comparison. This is followed by a detailed review of the Environmental, Social and Health Impact Assessment (ESHIA) reports of companies including Sierra Rutile, Vimetco, Socfin and Natural Habitat operating in the selected four chiefdoms in Moyamba and Pujehun in southern Sierra Leone.

The literature review captures the anticipated socio-economic and biophysical impacts of the aforementioned mining and multinational agricultural companies on host communities and their proposed mitigation strategies as enshrined in corresponding ESHMPs of companies. The implementation of corporate social responsibilities, as stated in community development agreements, is also reviewed across companies. Reviews obtained from the various company ESHIA reports are then compared with relevant sections of the land degradation assessment and national regulatory frameworks so as to provide an indication of compliance, with respect to national regulations, or an indication of the success or otherwise of the corporate social responsibilities and environmental remediation plans, with regards to the current assessment.

Given that three literature accounts; national environmental regulatory frameworks, company ESHIA reports and results of the current land degradation assessment, are reviewed in the comparative analysis, a hybrid comparative approach is adopted. First, the block or subject by subject method is used to review the aforementioned literature accounts. Then the alternating or point-by-point method is used to relate all aspects for an integrated comparative analysis.

CHAPTER THREE

3.0 Social and Economic Impact Assessment

This chapter presents findings obtained from socio-economic interviews on the perceived impacts of land degradation on the environment and livelihoods in the selected chiefdoms.

3.1 Socio-economic Characteristics of Respondents

In this study, the respondent population included household heads or their representatives, key informants drawn from stakeholders in the community, employees of private companies, youths, Non-Governmental Organisations (NGOs), public servants, and land rights activists.

3.1.1 Characteristics of Household Respondents

Table 6 presents the demographic characteristics of household heads across the communities surveyed; mining and non-mining communities in Moyamba District, and communities with multinational agricultural companies (MACs), and communities without MACs (non-MACs) in Pujehun District. In Moyamba District, there was a significant difference ($p < 0.005$) in the number of male- and female-headed households, with most households being male-headed. This finding is consistent with the findings of Kitula (2006) and Mansaray-Pearce *et al*. (2019) who conducted a study in both mining and non-mining communities in the district. In Pujehun, on the other hand, there were no significant differences ($p > 0.05$) in the number of male- and female-headed households. About two-thirds of the household heads were between the ages of 18 and 53, and this falls within the economically active or productive age bracket (Statistics Sierra Leone 2017). In Moyamba District, significant differences ($p < 0.005$) were observed in educational level between mining and non-mining localities, with respondents of at least a high school certificate being higher in mining communities (25%) than those in non-mining communities (6.8%). The average household size recorded in this study is higher than the household size of 5.4 reported for rural households by CFSVA (2015). The larger household sizes recorded in this study is attributable to the population growth brought by the migration of people to these areas in search of jobs. In the Pujehun District, no significant differences ($p > 0.05$) were observed for all demographic variables in the selected chiefdoms.

Table 6 Demographic characteristics of household respondents across the selected chiefdoms.

Variables	Moyamba			Pujehun			
	Community Type			Community Type			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining/ non-MAC	P-value
Gender			0.001*				0.077^{ns}
Male	69.1 (94)	86.4 (114)		92 (23)	91.1 (82)	81 (94)	
Female	30.9 (42)	13.6 (18)		8.0 (2)	8.9 (8)	19 (22)	
Age category (years)			0.755^{ns}				0.669^{ns}
18-26	13.2 (18)	9.8 (13)		4 (1)	4.4 (4)	5.2 (6)	
27-35	24.3 (33)	22.7 (30)		8(2)	15.6 (14)	24.1 (28)	
36-44	18.4 (25)	15.9 (21)		16 (4)	18.9 (17)	12.9 (15)	
45-53	19.9 (27)	25 (33)		24 (6)	22.2 (20)	21.6 (25)	
>53	24.3 (33)	26.5 (35)		48 (12)	38.9 (35)	36.2 (42)	
Educational level			0.001*				0.726^{ns}
None	31.6 (43)	37.9 (50)		36 (9)	31.1 (28)	26.7 (31)	
Quranic	11 (15)	25.8 (34)		40 (10)	43.3 (39)	41.4 (48)	
Primary	15.4 (21)	13.6 (18)		4.0 (1)	8.9 (8)	10.3 (12)	
JSS	11.8 (16)	12.1 (16)		4.0 (1)	2.2 (2)	8.6 (10)	
SSS	25.0 (34)	6.8 (9)		16 (4)	10 (9)	11.2 (13)	
College/tertiary	4.4 (6)	3.0 (4)		0 (0)	3.3 (3)	0.9 (1)	
University	0.7 (1)	0.8 (1)		0 (0)	1.1 (1)	0.9 (1)	
Household Size			0.565^{ns}				0.244^{ns}
1-4	11.8 (16)	6.8 (9)		4 (1)	2.2 (2)	6.9 (8)	
5-7	28.7 (39)	31.8 (42)		32 (8)	25.6 (23)	35.3 (41)	
8-10	28.7 (39)	30.3 (40)		44 (11)	34.4 (31)	30.2 (35)	
>10	30.9 (42)	31.1 (41)		20 (5)	37.8 (34)	27.6 (32)	

***Source**: LDA Field Survey Data, 2020*
**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

Table 7 presents the main occupation of household heads interviewed. Significant differences (p <0.05) were observed in the occupational distribution of respondents in the selected chiefdoms in Moyamba. Majority (72.8%) of the respondents in mining communities stated agriculture as their main occupation. Few respondents (7.4%) stated petty trading and only 5.9% stated mining and non-government employment as primary occupations. Within the non-mining communities in Moyamba, 91.7% of respondents stated agriculture as their major occupation, with few (3%) citing mining and 1.5% stating petty trading and non-government jobs. Furthermore, in the mining communities of Moyamba, few (1.5%) of respondents stated employment from agricultural companies as their main occupation, while in the non-mining communities, none of the respondents mentioned employment from agricultural companies.

Table 7 Occupational distribution of household heads across the selected chiefdoms.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining/non-MAC	P- value
Main occupation			0.014*				0.000*
Agriculture	72.8 (99)	91.7 (121)		76 (19)	68.9 (62)	83.6 (97)	
Mining	5.9 (8)	3 (4)		16 (4)	3.3 (3)	0 (0)	
Agric. company	1.5 (2)	0 (0)		0 (0)	11.1 (10)	9 (1)	
Petty business	7.4 (10)	1.5 (2)		4 (1)	2.2 (2)	5.2 (6)	
Government employment	1.5 (2)	0.8 (1)		4 (1)	0 (0)	1.7 (2)	
Non-government employment	5.9 (8)	1.5 (2)		0 (0)	1.1 (1)	0.9 (1)	
Unemployed	2.2 (3)	0.8 (1)		0 (0)	11.1 (10)	6.0 (7)	
Retired	2.9 (4)	0.8 (1)		0 (0)	2.2 (2)	1.7 (2)	

Source*: LDA Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

In Pujehun, there was a significant difference ($p < 0.005$) in the occupational distribution among respondents with majority (76%) of the household heads stating agriculture as their mainstay, 16% worked for mining companies, 4% stated both petty trading and government employment. In the MAC communities, majority (68.9%) of household heads depend on an agrarian livelihood, 11.1% on agricultural companies, 3.3% on mining, 2.2% on business, and 1.1% on non-government employment. Unemployment rate is highest (11.1%) in MAC communities, and this is attributable to a growing lack of access to arable land by farmers as agricultural companies continue to acquire large expenses of land. In the non-MAC/non-mining localities, (83.6%) of the respondents depend on farming incomes, with agricultural companies and petty business accounting for 9% and 5.2% of their incomes, respectively. Unemployment rate in non-MAC communities is very low (6%) as people still have access to their land for farming as against their MAC counterparts whose lands have been leased out.

FGDs on main sources of livelihoods in communities of industrial mining companies

In communities within Sierra Rutile and Vimetco concessions (Lower and Upper Banta), men, women and youths generally agreed that farming is their main source of livelihood followed by company jobs, petty trading, and bike riding by male youths. In the case of Lower Banta, charcoal production, teaching, fishing, small-scale mining, and artisanal craft works such as masonry, carpentry and welding were mentioned as additional sources of livelihoods.

FGDs on main livelihoods in communities with multinational agricultural companies

In Malen and Makpele where the Socfin Agricultural Company and Natural Habitat hold huge land concessions of oil palm plantations, respectively, farming, petty trading, company jobs and bike riding are the main livelihoods as articulated by respondents. Other livelihood sources, especially in Makpele, include artisanal diamond mining and charcoal production.

Table 8 presents the main sources of income for household respondents. In the non-mining communities in Moyamba, farming is the mainstay for 83.3% of the respondents and this is significantly ($p < 0.05$) higher than the 66.2% in mining communities. More income sources were mentioned by household respondents in mining communities than those in non-mining communities. In non-mining localities, 2.3% mentioned fishing/hunting as income sources.

Table 8 Primary income distribution of household heads across the selected chiefdoms.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining /non-MAC	P-value
Main Income Source			0.017*				0.019*
Charcoal burning	1.5 (2)	0 (0)		0 (0)	1.1 (1)	0 (0)	
Business/petty trading	8.1 (11)	4.5 (6)		8.0 (2)	3.3 (3)	6.9 (8)	
Driving/bike riding	2.9 (4)	1.5 (2)		4 (1)	0 (0.0)	2.6 (3)	
Salary from the companies	8.8 (12)	3.8 (5)		0 (0)	15.6 (14)	1.7 (2)	
Salary from other employment	4.4 (6)	2.3 (3)		4 (1)	1.1 (1)	5.2 (6)	
Fishing/hunting	0 (0)	2.3 (3)		0 (0)	0 (0)	0.9 (1)	
Farming (crops)	66.2 (90)	83.3 (110)		72 (18)	66.7 (60)	72.4 (84)	
Artisanal mining	2.2 (3)	1.5 (2)		0 (0)	7.8 (7)	6 (7)	
Others (specify)	5.9 (8)	0.8 (1)		12 (3)	4.4 (4)	4.3 (5)	

Source: *LDA Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

Similarly, in Pujehun, significant differences ($p < 0.05$) were observed in the distribution of respondents to mainstays. Farming is the major livelihood (66.7%) in surveyed communities. In Pujehun, petty trading is higher in mining communities than in MAC and non-mining communities. This can be attributed to an enabled business environment in operational areas of mining companies where salaries are higher relative to those in MACs and non-MACs.

Table 9 presents the distribution of secondary income sources among respondents. There are significant differences ($p < 0.05$) between the surveyed mining and non-mining communities in Moyamba. Business is more reported as a secondary income source (34.1%) in the non-mining communities. Other alternative income sources include charcoal production, bike riding, farming, fishing, and artisanal mining for both localities in Moyamba and Pujehun.

Table 9 Secondary income distribution of household heads across the study areas.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining/ non-MAC	P-value
Secondary income source			0.018*				0.000*
Charcoal production	2.9 (4)	2.3 (3)		0 (0)	6.7 (6)	1.7 (2)	
Business	24.3 (33)	34.1 (45)		20 (5)	14.4 (13)	18.1 (21)	
Driver/bike rider	1.5 (2)	2.3 (3)		0 (0)	0 (0)	3.4 (4)	
Sand/stone mining	1.5 (2)	0 (0)		0 (0)	8.9 (8)	0.9 (1)	
Salary from companies	5.1 (7)	0 (0)		0 (0)	8.9 (8)	0 (0)	
Salary from other employment	2.2 (3)	0.8 (1)		0 (0)	1.1 (1)	2.6 (3)	
Fishing	2.9 (4)	6.1 (8)		0 (0)	3.3 (3)	2.6 (3)	
Farming	46.3 (63)	50 (66)		68 (17)	33.3 (30)	46.6 (54)	
Artisanal mining	4.4 (6)	2.3 (3)		0 (0)	13.3 (12)	6 (7)	
Others (specify)	8.8 (12)	2.3 (3)		12 (3)	10 (9)	18.1 (21)	

Source*: LDA Field Survey Data, 2020*
**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*
NB: Figures in parentheses are frequencies and those out of parentheses are percentages

In Pujehun, there are significant differences ($p < 0.005$) among mining communities, MAC communities and non-MAC/non-mining communities with regards to farming being a secondary income source. In mining communities, 68% reported farming as a secondary income source relative to 33.3% in MAC communities and 46.6% in non-MAC/non-mining communities. Mining in Pujehun is mostly at the artisanal scale and therefore there are more lands available to farmers in mining communities than in operational areas of MACs where significant portions of arable land have been leased out to either Socfin or Natural Habitat.

Table 10 presents the number of households that have leased out arable land to companies. In Moyamba, significant differences ($p < 0.05$) are observed between mining and non-mining communities. In the mining localities, 37 out of 136 households indicated they have leased out land to companies whereas only 1 out of 132 households in the non-mining areas reported to have leased out land. In Pujehun, significant differences ($p < 0.005$) were also observed as out of 90 households sampled in MAC communities, 46 reported to have leased out lands to companies, and in mining communities only 2 out of 25 households indicated they have leased out land to companies. In the non-MAC/non-mining localities in Pujehun, none of the households had leased out land to companies. Thus land lease is mostly in areas of MACs.

Table 10 Land lease dynamics among households in the surveyed communities.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining/non-MAC	P-value
Leased land			0.000*				0.000*
Yes	27.2 (37)	0.8 (1)		4 (1)	51.1 (46)	0 (0)	
No	66.9 (91)	37.1 (49)		92 (23)	(5.6 (32)	39.7 (46)	
Not applicable	5.9 (8)	62.1 (82)		4 (1)	13.3 (12)	60.3 (70)	

***Source**: LDA Field Survey Data, 2020*
**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*
NB: Figures in parentheses are frequencies and those out of parentheses are percentages

Table 11 presents the percentage of households that have leased all their arable lands and the distribution of alternative income sources among households that have leased out all lands to companies. In the mining communities of Moyamba, about 18.9% of households have leased all their arable lands. This situation is more critical in Pujehun where 58.7% of households in MAC communities have leased all their arable lands. Majority of the respondents however stated that they were either forced into, or deceived in, such lease agreements. These findings agreed well with those of FIAN International in 2019 which stated that landowners and land users immediately denounce lease agreements as illegitimate and organized themselves into the Malen Land Owners Association (MALOA). In an effort to resolve the land crisis in Malen Chiefdom, they detailed their concerns in a letter to the Pujehun District authorities on 2nd October 2011. Their grievances included but not limited to; a lack of consultation of landowners prior to lease agreements, pressure, intimidation and threats aimed at coercing landowners to sign over their lands, corruption and inadequate/or non-payment of compensation.

Table 11 Percentage of households that have leased all their lands and their alternative livelihoods.

Variables	Moyamba			Pujehun		
	Mining community	Non-mining community	P-value	Mining community	MAC community	P-value
Leased all arable land?			0.63^{ns}			0.24^{ns}
Yes	18.9 (7)	0 (0)		0 (0)	58.7 (27)	
No	81.1 (30)	100 (1)		100 (1)	41.3 (19)	
Alternative livelihood			0.94^{ns}			0.32^{ns}
Animal rearing	10.8 (4)	0 (0)		100 (1)	13 (6)	
Business	35.1 (13)	100 (1)		0 (0)	19.6 (9)	
Employment from company	10.8 (4)	0 (0)		0 (0)	23.9 (11)	
Employment from other source	5.4 (2)	0 (0)		0 (0)	2.2 (1)	
Timber logging	2. 7(1)	0 (0)		0 (0)	0 (0)	
Artisanal mining	5.4 (2)	0 (0)		0 (0)	17.4 (8)	
Others (specify)	29.7 (11)	0 (0)		0 (0)	23.9 (11)	

Source*: LDA Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

In Moyamba, no significant difference ($p > 0.05$) in alternative livelihoods was observed**.** About 35% of the respondents were engaged in petty trading, and 10.8% were recorded for both animal rearing and employment in mining companies. Few respondents (5.4%) were engaged in artisanal mining and as little as 2.7% were engaged in timber logging in the mining communities. Due to the significant land dispossession in Pujehun, especially Malen, 23.9% of the respondents now depend on company jobs. Furthermore, 19.6% are engaged in business, 17.4% in artisanal mining, and 13% in animal rearing as alternative livelihoods. Table 12 presents a pair-wise ranking of alternative livelihoods in the mining communities. It is observed in Table 12 that business is the highest ranked alternative livelihood in mining communities, followed by other livelihoods specified as bike riding, tailoring, and animal rearing. Jobs from the extractive industries and other sectors ranked 4th and 5th, respectively. Artisanal mining ranked 6th and this activity is mostly conducted at small scales without legal standing. Table 13 presents a pair-wise ranking of the main alternative livelihoods in MACs.

Table 12 Pair-wise ranking of alternative livelihoods of household heads in mining communities.

Alternative livelihoods	1	2	3	4	5	6	7	Rank
1=Animal rearing								3rd
2=Business	2							1st
3=Employment in the company	1	2						4th
4=Employment in other work	1	2	3					5th
5=Timber logging	1	2	3	4				7th
6=Artisanal mining	1	2	3	4	6			6th
7=Others (specify)	7	2	7	7	7	7		2nd
Frequency	**4**	**6**	**3**	**2**	**0**	**1**	**5**	

***Source**: LDA Field Survey Data, 2020*

Table 13 Pair-wise ranking of alternative livelihoods of households in MAC communities.

Alternative livelihoods	1	2	3	4	5	6	Rank
1=Animal rearing							5th
2=Business	2						3rd
3=Employment in the company	3	3					1st
4=Employment in other work	1	2	3				6th
5=Artisanal mining	5	2	3	5			4th
6=Others (specify)	6	6	3	6	6		2nd
Frequency	**1**	**3**	**5**	**0**	**2**	**4**	

***Source**: LDA Field Survey Data, 2020*

In Table 13, the highest ranked alternative livelihood is company jobs, others including bike riding and charcoal production were ranked second, followed by business, artisanal mining, animal rearing and employment from other sectors such as NGOs and government service.

3.1.2 Characteristics of Key Informants

Table 14 presents the characteristics of respondents selected for the KIIs in the study areas. It can be seen that there are no significant ($p > 0.05$) differences in gender although most of the key informants in both districts were males. In Moyamba, significant differences ($p < 0.05$) were observed with regards to educational level among respondents. In mining communities, 51.4% of the key informants went through formal education as against 54.3% in non-mining areas. No significant ($p > 0.05$) differences in educational level were recorded in Pujehun.

Table 14 Demographic characteristics of key informants across the study areas.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining /non-MAC	P-value
Sex			0.927ns				0.409 ns
Male	67.6 (25)	68.6 (24)		60 (3)	73.9 (17)	83.9 (26)	
Female	32.4 (12)	31.4 (11)		40 (2)	26.1 (6)	16.1 (5)	
Marital status			0.299 ns				0.023**
Single	5.4 (2)	2.9 (1)		20 (1)	0 (0)	0 (0)	
Married	94.6 (35)	91.4 32)		80 (4)	95.7 (22)	93.5(29)	
Widowed	0 (0)	5. 7(2)		0 (0)	4.3 (1)	6.5 (2)	
Educational status			0.045 **				0.608 ns
None	48.6 (18)	22.9 (8)		40 (2)	43.5 (10)	25.8 (8)	
Quranic	0 (0)	22.9 (8)		40 (2)	26.1 (6)	41.9(13)	
Primary	13.5 (5)	11.4 (4)		0 (0)	13 (3)	9.7 (3)	
JSS	10.8 (4)	14.3 (5)		0 (0)	8.7 (2)	0 (0)	
SSS	18.9 (7)	14.3 (5)		20 (1)	0 (0)	9.7 (3)	
College/Technical	5.4 (2)	8.6 (3)		0 (0)	4.3 (1)	6.5 (2)	
University	2.7 (1)	5.7 (2)		0 (0)	4.3 (1)	6.5 (2)	
Position/title			0.431 ns				0.667 ns
Chief/headman	29.7 (11)	31.4 (11)		40 (2)	34.8 (8)	35.5 (11)	
Women's leader	27 (10)	22.9 (8)		40 (2)	26.1 (6)	19.4 (6)	
Youth leader	32.4 (12)	20 (7)		20 (1)	30.4 (7)	19.4 (6)	
MAF official	0 (0)	2.9 (1)		0 (0)	4.30 (1)	3.2 (1)	
Others (specify)	10.8 (4)	22.9 (8)		0 (0)	4.30 (1)	22.6 (7)	
Age group			0.372 ns				0.914 ns
18-26 years	2.7 (1)	0 (0)		0 (0)	0 (0)	3.2 (1)	
27-35 years	34.4 (12)	22.9 (8)		20 (1)	30.4 (7)	19.4 (6)	
36-44 years	16.2 (6)	8.6 (3)		20 (1)	13 (3)	6.5 (2)	
45-53 years	16.2 (6)	31.4 (11)		20 (1)	21.7 (5)	22.6 (7)	
>53 years	34.4 (12)	37.1 (13)		40 (2)	34.8 (8)	48.4 (15)	

Source*: LDA Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

On the designations of the key informants in the mining localities of Moyamba, 29.7% were chiefs, 27% were women leaders and 34.2% were youth leaders. The insignificant difference in the number of women leaders in the sample size relative to other designations implies little or no gender bias in the assumption of community authority in mining areas. In the non-mining areas, 31.4% of the informants were chiefs, 22.9% were women leaders, 20% were youth leaders, 22.9% occupied other positions, and 2.9% were officials of the Ministry of Agriculture and Forestry (MAF). In Pujehun, key informants mainly include chiefs, women and youth leaders or those holding other specified positions, with a few being MAF officials. With respect to age groups within the surveyed communities, few key informants were within the age brackets of 18 and 26, with most being above the age of 53. This indicates that a high percentage of the key informants who are natives of these communities possess sufficient historical knowledge of the impacts of companies on community resources and livelihoods. Table 15 presents the perceptions of key informants on community main income sources.

Table 15 Perceptions of key informants on the main income sources of community people.

Variables	Moyamba			Pujehun			
	Mining Community	Non-mining Community	P-value	Mining Community	MAC Community	Non-mining/ non-MAC	P-value
Primary (main) income source			0.22^{ns}				0.8^{ns}
Charcoal burning	2.7 (1)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Business	5.4 (2)	2.9 (1)		0 (0.0)	0 (0.0)	3.2(1)	
Salary from other employment	0 (0.0)	8.6 (3)		0 (0.0)	4.3 (1)	3.2 1)	
Farming	91.9 (34)	88.6 (31)		100 (5)	91.3 (21)	87.1 (27)	
Artisanal mining	0 (0.0)	0 (0.0)		0 (0.0)	4.3 (1)	0 (0.0)	
Others (specify)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	6.5 (2)	

***Source**: LDA Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

It can be observed in Table 15 that there are no significant ($p < 0.05$) differences in the main sources of income between communities of the two districts, with farming being the primary source of income in all communities surveyed. In Moyamba, other income sources included salaries from other employment (8.6%), business (8.3%) and charcoal production (2.7%). In Pujehun, the other sources of income (6.5%) included bike riding and fishing/hunting. Salaries from other employment were indicated by 4.3% of the respondents in MAC areas and 3.2% by respondents in non-mining/non-MAC communities. In the surveyed localities in Pujehun, artisanal mining and business were mentioned as economic activities by 4.3% and 3.2% of key informants in MAC and non-mining/non-MAC communities, respectively. Table 16 presents the secondary income sources of indigenes as perceived by the key informants.

Table 16 Perceptions of key informants on secondary income sources of community people.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC Community	Non-mining /non-MAC community	P-value
Secondary (alternative) source			0.642^{ns}				0.001*
Charcoal production	5.4 (2)	8.6 (3)		0 (0)	4.3 (1)	0 (0)	
Business	48.6 (18)	37.1 (13)		0 (0)	21.7 (5)	38.7 (12)	
Driver/bike rider	0 (0)	2.9 (1)		0 (0)	4.3 (1)	3.2(1)	
Sand/stone miner	2.7 (1)	0 (0)		20 (1)	0 (0)	0 (0)	
Salary from a company job	2.7 (1)	2.9 (1)		0 (0)	26.1 (6)	0 (0)	
Salary from other employment	2.7 (1)	0 (0)		0 (0)	0 (0)	0 (0)	
Fishing/hunting	2.7 (1)	2.9 (1)		0 (0)	0 (0)	6.5 (2)	
Farming	18.9 (7)	31.4 (11)		80 (4)	8.7 (2)	22.6 (7)	
Artisanal mining	5.4 (2)	0 (0)		0 (0)	4.3 (1)	12.9 (4)	
Others (specify)	10.8 (4)	14.3 (5)		0 (0)	30.4 (7)	16.1 (5)	

***Source**: LDA Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

In Table 16, there are no significant ($p > 0.05$) differences in the secondary sources of income between the mining and non-mining localities in Moyamba. However, key informants stated petty trading as the main secondary means of livelihood. In the mining localities of Pujehun, farming and sand/stone mining were the only secondary sources. In the MACs in Pujehun, company jobs, petty trading and others were stated as secondary livelihoods for indigenes. Fishing/hunting are also secondary sources of income in non-mining/non-MAC communities.

3.1.3 Characteristics of Employee Interview Respondents

Company employee interviews were only conducted in Pujehun where Socfin and Natural Habitat operate in Malen and Makpele, respectively. Interviews were not granted for Sierra Rutile and Vimetco in Moyamba, apparently due to COVID-19 measures. Table 17 presents the socio-economic characteristics of respondents of employee interviews. In both chiefdoms, majority of the respondents were males. In Makpele, 60% of the respondents were between age 18 and 35, and a similar pattern was recorded among employee respondents in Malen. In Makpele, 90% of the respondents went through formal education as against a 100% in Malen.

In Malen, all employees interviewed were permanent staff, while in Makpele, 3 out of the 10 employees interviewed were casual workers and can be terminated without notice or end of service benefit. There is a significant difference (p <0.05) in the employment of indigenes between the two chiefdoms. In Makpele, 7 out of the 10 employees were indigenes while in Malen only 2 out of the 10 employees were indigenes. Companies were reported as the main income source in both chiefdoms. For Natural Habitats, 20% of the workers cited business as a secondary income source, while in Malen, employees also mentioned farming and business.

Table 17 Socio-economic characteristics of company employees.

Variables	**Chiefdom**		
	Makpele	Malen	P - value
Gender			-
Male	100 (10)	100 (10)	
Female	0 (0)	0 (0)	
Age category			0.572^{ns}
18-26 years	10 (1)	0 (0)	
27-35 years	50 (5)	50 (5)	
36-44 years	40 (4)	40 (4)	
>53 years	0 (0)	10 (1)	
Educational status			
None	10 (1)	0 (0)	0.103^{ns}
Primary	10 (1)	0 (0)	
JSS	20 (2)	0 (0)	
SSS	30 (3)	50 (5)	
College/technical	20 (2)	0 (0.0)	
University	10 (1)	50 (5)	
Are you an indigene?			
If yes, from where?	70 (7)	20 (2)	0.056*
Within chiefdom	0 (0)	10 (1)	
Within district	10 (1)	0 (0)	
Outside of district	20 (2)	70 7)	
Status of employment			0.060^{ns}
Casual labour	30 (3)	0 (0)	
Full employment	70 (7)	100 (10)	
Main source of income			
Company? or specify	100 (10)	100 (10)	
Secondary source of income			0.149^{ns}
Business	20 (2)	20 (2)	
Salary from company	80 (8)	40 (4)	
Farming	0 (0)	20 (2)	
Others (specify)	0 (0)	20 (3)	

Source: *Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

3.2 Impacts of Mining and MAC Activities on Human Welfare

3.2.1 Impacts on Water Quality

3.2.1.1 Perceptions on water quality from household respondents

Table 18 presents the perceptions obtained from respondents of household interviews on the impacts of the activities of mining and MACs on the water quality across the four chiefdoms. It is observed in Table 18 that significant differences ($p < 0.05$) exist in the perceptions on water quality between communities in Moyamba District. In mining areas, 71.3% of the respondents stated the deterioration in water quality that is attributable to mining activities, as against 53% of the respondents who hold a similar view in non-mining communities. Significant differences ($p < 0.05$) in the perceptions on water quality between communities were also recorded in Pujehun where 51.1% of the respondents in MAC communities reported a decline in water quality, and this they largely attributed to the activities of agricultural companies that have degraded important watersheds. It is further observed that respondents in mining communities in Moyamba are less dependent on rivers and streams for domestic water use (33.8%) relative to those in non-mining communities (87.9%). This is not unconnected to the reduced water quality in rivers and streams in mining communities, against which alternative water supply sources like wells and taps have been constructed. A similar pattern is observed in Pujehun where 60% of the respondents in mining communities depend on water wells as against 32.2% in MAC communities. On the physical condition of drinking water, 35.3% of the respondents in mining communities observed it to be tasteless and colourless as against 53.3% in MAC localities, implying that water is generally perceived to be of poorer quality in mining communities. There are, however, no observed significant differences ($p > 0.05$) in the availability and accessibility of water across the communities.

Table 18 Perceptions of household respondents on the impacts of mining and MACs on water quality.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining /non-MAC	P-value
Changes to underground and surface water quality			0.000*				0.031*
Deteriorated	71.3 (97)	53 (70)		24 (6)	51.1 (46)	32.8 (38)	
Unchanged	15.4 (21)	40.9 (54)		60 (15)	27.8 (25)	44.8 (52)	
Improved	13.2 (18)	3 (4)		16 (4)	21.1 (19)	21.6 (25)	
Don't know	0 (0)	3 (4)		0 (0)	0 (0)	0.9 (1)	
Main source of drinking water			0.000*				0.002*
River/stream	33.8 (46)	87.9 (116)		8 (2)	24 (22)	37.9 (44)	
Well	36 (49)	11.40 (15)		60 (15)	32.2 (29)	27.6 (32)	
Borehole	22.1 (30)	0.8 (1)		28 (7)	18.9 (17)	20.7 (24)	
Tap	6.6 (9)	0 (0)		4 (1)	24.4 (22)	13.8 (16)	
Others (specify)	1.5 (2)	0 (0)		-	-	-	
Condition of water			0.000*				0.004*
Have taste and colour	41.2 (56)	68.2 (90)		12 (3)	18.9 (17)	22.4 (26)	
Tasteless but have colour	14.7 (20)	15.2 (20)		0 (0)	10 (9)	18.1 (21)	
Have taste but colourless	8.8 (12)	4.5 (6)		0 (0)	17.80 (16)	10.3 (12)	
Tasteless and colourless	35.3 (48)	12.1 (16)		88 (22)	53.3 (48)	49.1 (57)	
Availability and accessibility			0.904^{ns}				0.104^{ns}
Yes	89.7 (122)	90.2 (119)		100 (25)	93.3 (84)	87.9 (102)	
No	10.30 (14)	9.8 (13)		0 (0)	6.7 (6)	12.1 (14)	

***Source**: LDA Field Survey Data, 2020*

**: Test statistics significant (P<0.05)　　　　ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

3.2.1.2 Perceptions on water quality from key informants

Table 19 presents the perceptions of key informants on water quality in the areas under study. In the mining communities of Moyamba, majority (70.3%) of key informants described the water condition as poor, although 10% believed that the water condition was already poor even before the resumption of mining operations. This perception reduced to 60% in non-mining communities. With similar views obtained from household respondents, this suggests that mining is generally perceived to have more negative impacts on water quality. Moreover, 70.3% of the respondents believed that safe drinking water was readily available before the start of mining, but this reduced to 48.6% of respondents who hold this view under mining.

Table 19 Perceptions of key informants on the impacts of mining and MACs on water quality.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining/non-MAC	P-value
Present water condition			0.906^{ns}				9.862^{ns}
Bad	70.3 (26)	60 (21)		0 (0)	8.7 (2)	25.8 (8)	
Moderate	24.3 (9)	34.3 (12)		20 (1)	65.2 (15)	51.6 (16)	
Good	5.4 (2)	5.7 (2)		80 (4)	26.1 (6)	22.6 (7)	
Water condition before company operations			0.015**				0.360^{ns}
Bad	10.8 (4)	31.4 (11)		20 (1)	13 (3)	32.3 (10)	
Moderate	27 (10)	28.6 (10)		40 (2)	69.6 (16)	38.7 (12)	
Good	62 (23)	31.4 (11)		40 (2)	17.4 (4)	25.8 (8)	
Don't know	0 (0)	8.6 (3)		0 (0)	0 (0)	3.2 (1)	
Availability/accessibility of pure water			0.612^{ns}				0.001*
Not readily available	48.6 (18)	57.1 (20)		0 (0)	21.7 (5)	25.8 (8)	
Fairly available	18.6 (7)	14.3 (5)		0 (0)	9.7 (16)	35.5 (11)	
Available and accessible	32.4 (12)	25.7 (9)		100 (5)	8.7 (2)	38.7 (12)	
Don't know	0 (0)	2.9 (1)		0 (0)	0 (0)	0 (0)	
Availability/accessibility of pure water before company operations			0.334^{ns}				0.052*
Not readily available	18.9 (7)	25.7 (9)		20 (1)	8.7 (2)	19.4 (6)	
Fairly available but not accessible	10.8 (4)	14.3 (5)		0 (0)	65.2 (15)	35.5 (11)	
Accessible and available at all times	70.3 (26)	54.3 (19)		80 (4)	26.1 (6)	45.2 (14)	
Don't know	0 (0)	5.7 (2)		0 (0)	0 (0)	0 (0)	

***Source**: Field Survey Data, 2020*
**: Test statistics significant (P<0.05) ns= Test statistics non-significant (P>0.05)*
NB: Figures in parentheses are frequencies and those out of parentheses are percentages

3.2.1.3 Perceptions on water quality from focus group discussions

In Lower Banta, there is generally no perceived negative impact of mining on water quality as they rely on water wells and taps. However, a good number of wells dry up at the late dry season and some taps are also not working. Some have therefore resorted to an artificial lake for domestic water. In Upper Banta, there are perceived negative impacts of mining on water quality. Responses noted the contamination of water by chemical wastes from mining sites. There are few protected wells and women, and children travel long distances to fetch water.

In Malen, residents attested to an improvement in water supply with the provision of hand-pumped water wells by Socfin. There are also no perceived negative impacts of Socfin operations on water quality. However, water supply facilities provided by Socfin were not considered adequate in meeting the domestic water needs of the indigenes and this they have communicated to the authorities. Similarly, there is perceived improvement in water supply in Makpele which is attributable to the activities of Gola Rainforest National Park and NGOs like World Vision and GTZ, and not to Natural Habitats which owns oil palm plantations.

3.2.2 Impacts on Land Tenure and Land Quality

3.2.2.1 Perceptions on land tenure and land surface quality from household respondents

Table 20 presents the perceptions of household respondents on the impacts of mining and MACs on land tenure systems and accessibility to, and quality of, land in their communities. In Table 20, significant differences ($p < 0.05$) in perceptions on land tenure can be observed between mining and non-mining communities in Moyamba, with 54% of respondents in the former stating a change in land tenure as against 18.2% who held a similar view in the later.

Table 20 Household perceptions on mining and MAC impacts on land tenure and land quality.

Variables	**Moyamba**			**Pujehun**			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining /non-MAC	P-value
Changes to land tenure			0.000*				0.000*
Improved	14 (19)	4.5 (6)		36 (9)	3.3 (3)	12.1 (14)	
Deteriorated	54 (74)	13.6 (18)		12 (3)	66.7 (60)	18.1 (21)	
Unchanged	31.6 (43)	81.8 (108)		52 (13)	30 (27)	69.8 (81)	
Access to arable land			0.004*				0.000*
Yes	87.5 (119)	97 (128)		100 (25)	76.7 (69)	94 (109)	
No	12.5 (17)	3 (4)		0 (0)	23.3 (21)	6 (7)	
Arable land sufficient?			0.000*				0.000*
Yes	56.3 (67)	82.8 (106)		100 (25)	52.2 (36)	91.7 (100)	
No	43.7 (52)	17.2 (22)		0 (0)	47.8 (33)	8.3(9)	
Effect on land quality			0.000*				0.000*
Positive impact	1.5 (2)	6.1 (8)		4 (1)	1.1 (1)	0 (0)	
Negative impact	91.2 (124)	41.7 (55)		40 (10)	56.7 (51)	8.6 (10)	
No impact	7.4 (10)	52.3 (69)		56 (14)	42.2 (38)	91.4 (106)	
Impact on ecosystems			0.000*				0.000*
Positive impact	1.5 (2)	4.5 (6)		0 (0)	3.3 (3)	1.7 (2)	
Negative impact	93.4 (127)	34.8 (46)		40 (10)	54.4 (49)	11.2 (13)	
No impact	5.1 (7)	60.6 (80)		60 (15)	42.2 (38)	87.1 (101)	

Source*: LDA Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

In Pujehun, land tenure systems are perceived to have significantly deteriorated in MAC communities (66.7% of respondents) while only 12% of the respondents in mining localities and 18.1% of the respondents in non-mining/non-MAC localities perceived a deterioration of the land tenure systems. Significant differences ($p < 0.05$) between communities are noted in the accessibility to land, with households in MAC areas having less access to arable land.

It is also observed in Table 20 that significant differences ($p < 0.05$) exist in respondents' perceptions on land surface quality between mining and non-mining localities in Moyamba. Majority (91.2%) of the respondents in mining communities perceived deterioration in land quality as against 41.7% who hold a similar perception in non-mining communities. In Pujehun, a decline in land surface quality was perceived by 56.7% of the respondents in MAC communities relative to 40% who hold a similar perception in mining communities. In Pujehun, mining is mostly small-scaled or artisanal and could therefore have a lesser impact on land quality than large scale agricultural activities. In Moyamba, significant differences ($p < 0.05$) are recorded on perceptions of company impacts on ecosystem services between mining and non-mining communities. Majority (93.4%) of respondents in mining localities perceived company activities as having a negative impact on ecosystems relative to 40% who hold this view in non-mining communities. In Pujehun, while 54.4% of the respondents in MAC communities considered the activities of companies as having a negative impact on ecosystem services, only 12.9% hold a similar view in non-mining/non-MAC communities.

3.2.2.2 Perceptions on land tenure and land surface quality from key informants

Table 21 presents the perceptions of key informants on land tenure and land quality in their localities. In Moyamba, 91.6% of the respondents believed that land was sufficiently available before mining operations. With the advent of mining, only 8.1% still hold this view. In MAC localities, 82.6% of the key informants indicated sufficient arable land availability before the start of company operations. Respondents holding this view under current MAC operations only account for 26.1% of the key informants. Similar to responses obtained from household interviews, majority of the key informants (83.8%) hold the view that mining operations have negatively affected land quality. In non-mining areas, 34.3% of the key informants acknowledged the negative impacts of mining on land quality. In Pujehun, 47.8% of the key informants attributed the declining land surface quality to the activities of MACs.

Table 21 Perceptions of key informants on the availability and quality of arable land.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining/non-MAC	P-value
Is land Availability for farming?			0.000*				0.003*
Hardly available	37.8 (14)	5.7 (2)		0 (0)	39.1 (9)	3.2 (1)	
Available but not sufficient	51.4 (19)	34.3 (12)		40 (2)	34.8 (8)	29 (9)	
Sufficiently available	8.1 (3)	57.1 (20)		60 (3)	26.1 (6)	67.7 (21)	
Don't know	2.7 (1)	2.9 (1)		0 (0)	0 (0)	0 (0)	
Was land available for farming before company arrival?			0.104ns				0.687ns
Hardly available	0 (0)	0 (0)		0 (0)	4.3 (1)	0 (0)	
Available but not sufficient	8.1 (3)	8.6 (3)		0 (0)	13 (3)	19.4 (6)	
Sufficiently available	91.6 (34)	80 (28)		100 (5)	82.6 (19)	77.4 (24)	
Don't know	0 (0)	11.4 (4)		0 (0)	0 (0)	3.2 (1)	
Effect on land quality			0.000*				0.001*
Positive	5.4 (2)	5.7 (2)		100 (5)	47.8 (11)	16.1 (5)	
Negative	83.8 (31)	34.3 (12)		0 (0)	47.8 (11)	83.9 (26)	
No impact	8.1 (3)	54.3 (19)		0 (0)	4.3 (1)	0 (0)	
Don't know	2.7 (1)	5.7 (2)		0 (0)	0 (0)	0 (0)	
Impact on ecosystems			0.000*				0.012*
Loss	83.8 (31)	42.9 (15)		60 (3)	52.2 (12)	12.9 (4)	
Remediation	5.4 (2)	0 (0)		0 (0)	17.4 (4)	6.5 (2)	
Stable	5.4 (2)	40 (14)		40 (2)	30.4 (7)	74.2 (23)	
Don't know	5.4 (2)	17.1 (6)		0 (0)	0 (0)	6.5 (2)	

Source*: LDA Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

3.2.2.3 Perceptions on land tenure and land quality from focus group discussions

There are perceived changes in land tenure systems across the study areas and this is largely attributable to the acquisition of large tracts of land by mining and agricultural companies. Access to farmland is becoming extremely difficult, especially for women. In Lower Banta, farms within or proximal to mines are sometimes destroyed with little or no compensation. In Upper Banta, a significant portion of arable land has also been leased to mining companies.

In Malen, respondents stated that much of their lands have been acquired by Socfin and majority of the indigenes have little or no access to farmland. Other livelihoods including hunting, harvesting medicinal plants, lumbering, and charcoal production have been eroded due to the lack of access to land. In Makpele, on the other hand, participants stated that land is available but access to it is gradually declining with the expansion in oil palm plantations.

3.2.3 Impacts on Employment, Health and Infrastructure

3.2.3.1 Perceptions on employment, health and infrastructure from household heads

Table 22 presents the perceptions of respondents on the impacts of mining and MACs on employment, health and infrastructure in the chiefdoms under study. In Moyamba, only 13.2% of the respondents in mining communities considered the employment opportunities as having a positive impact on local livelihoods. This reduced to 11.4% in non-mining areas. In Pujehun, employment is higher in MAC localities than in non-mining/non-MAC localities.

On human health, 70.6% of the respondents in mining communities in Moyamba indicated negative health impacts due to air and water pollutants from mine sites. The few positive impacts of mining companies on human health relate to the rehabilitation or construction of health centres by mining companies. In Pujehun, 41.1% of the respondents in MAC areas considered the activities of companies as having a negative impact on local communities. The 2.2% of the respondents that hold a contrary view in MAC operational areas indicated the rehabilitation/construction of health centres, supply of drugs and equipment, and availability of trained medical staff as some of the major positive impacts of companies on human health.

On infrastructure, only 4.4% of the respondents in mining areas in Moyamba considered company activities to have had a positive impact as against 21.1% in MAC areas in Pujehun. This suggests that agricultural companies in Malen and Makpele are generally perceived by locals to be more responsive to community needs, and by extension, community development agreements, as against the mining companies under review in Lower Banta and Upper Banta.

Table 22 Perceptions on the impacts of mining and MACs on employment, health and infrastructure.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining /non-MAC	P-value
Impact on employment opportunities			0.000*				0.000*
Positive	13.2 (18)	11.4 (15)		4 (1)	22 (24.4)	12.1 (14)	
Negative	58.1 (79)	28.8 (38)		16 (4)	22 (24.4)	9.5 (11)	
No impact	28.7 (39)	59.8 (79)		80 (20)	46 (51.1)	78.4 (91)	
Impact on health			0.005*				0.000*
Positive impact	3.70 (5)	0.8 (1)		0 (0)	2.2 (2)	0 (0)	
Negative impact	70.6 (96)	56.1 (74)		20 (5)	41.1 (37)	11.2 (13)	
No impact	25.7 (35)	43.2 (57)		80 (20)	56.7 (51)	88.8 (103)	
If positive, what types of facilities are provided?							
Rehabilitation/ construction of health centres	100 (5)	0 (0)		0 (0)	33.3 (2)	0 (0)	
Drugs and equipment	0 (0)	0 (0)		0 (0)	33.3 (2)	0 (0)	
Provision of expatriate	0 (0)	0 (0)		0 (0)	33.3 (2)	0 (0)	
Impact on infrastructure			0.001*				0.000*
Positive impact	4.4 (6)	0.8 (1)		8 (2)	21.1 (19)	0 (0)	
Negative impact	53.7 (73)	36.4 (48)		20 (5)	20 (18)	7.8 (9)	
No impact	41.9 (57)	62.9 (83)		72 (18)	58.9 (53)	92.2 (107)	

***Source**: LDA Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

3.2.3.2 Perceptions on employment, health and infrastructure from key informants

The perceptions of key informants on the impacts of mining and MACs on job opportunities, healthcare and infrastructure in the chiefdoms under investigation are provided in Table 23.

In Moyamba, 54.1% of the key informants indicated that companies have not made positive impacts on employment as indigenes hardly benefit from company job opportunities. A similar view is held by 52.3% of the respondents in MAC communities in Pujehun. On healthcare, more positive impacts were reported in MAC communities than in mining communities. In the mining areas of Moyamba, 2.7% of key informants stated that residents, especially adult females, have benefited from health facilities provided by companies. In MAC localities, 30.4% of the key informants believed that beneficiaries of health facilities provided by companies are mostly adult males, suggesting that such beneficiaries are mostly company employees. In Moyamba, 97.3% of the key informants indicated indigenes have not recorded much infrastructural development with Sierra Rutile and Vimetco. In MACs, 34.8% of the key informants stated that residents have benefited from infrastructure built by Socfin, and these include haul roads, schools, recreational and health centres, and places of worship.

Table 23 Key informant perceptions on company impacts on employment, heath and infrastructure.

Variables	Moyamba			Pujehun			
	Mining community	Non-mining community	P-value	Mining community	MAC community	Non-mining/non-MAC	P-value
Impact on employment			0.003*				0.000*
Positive	8.1 (3)	8.6 (3)		40 (2)	4.3 (1)	19.4 (6)	
Negative	54.1 (20)	14.3 (5)		0 (0)	52.2 (12)	3.2 (1)	
No impact	37.8 (14)	17.4 (25)		60 (3)	43.5 (10)	77.4 (24)	
Don't know	0 (0)	5.7 (2)		-	-	-	
Impact on healthcare			0.000*				0.229^{ns}
Positive	2.7 (1)	0 (0)		0 (0)	17.4 (4)	6.5 (2)	
Negative	78.4 (29)	31.4 (11)		20 (1)	26.1 (6)	9.7 (3)	
No impact	18.9 (7)	65.7 (23)		80 (4)	56.5 (13)	83.9 (26)	
Don't know	0 (0)	2.9 (1)					
Beneficiaries of health facilities			0.523^{ns}				0.032*
Yes	2.7 (1)	5.7 (2)		0 (0)	30.4 (7)	6.5 (2)	
No	97.3 (36)	94.3 (33)		100 (5)	69.6 (16)	93.5 (29)	
Who are the main beneficiaries?			0.386^{ns}				0.360^{ns}
Everybody	0 (0)	0 (0)		0 (0)	28.6 (2)	100 (2)	
Adult males	0 (0)	50 (1)		0 (0)	42.9 (3)	0 (0)	
Adult females	100 (1)	50 (1)		0 (0)	14.3 (1)	0 (0)	
Children	0 (0)			0 (0)	14.3 (1)	0 (0)	
Do locals benefit from the infrastructure?			0.523^{ns}				0.013*
Yes	2.7 (1)	5.7 (2)		0 (0)	34.8 (8)	6.5 (2)	
No	97.3 (36)	94.3 (33)		100 (5)	65.2 (15)	93.5 (29)	
If yes, what are the facilities?							
Road network	0 (0)	0 (0)		0 (0)	16.7 (3)	0 (0)	
Schools	0 (0)	0 (0)		0 (0)	16.7 (3)	0 (0)	
Community centre	100(1)	0 (0)		0 (0)	22 (4)	0 (0)	
Health centre	0 (0)	0 (0)		0 (0)	16.7 (3)	0 (0)	
Place of worship	0 (0)	0 (0)		0 (0)	5.6 (1)	0 (0)	
Others (specify)	0 (0)	0 (0)		0 (0)	22 (4)	0 (0)	

Source: *Field Survey Data, 2020*

**: Test statistics significant (P<0.05)* *ns= Test statistics non-significant (P>0.05)*
NB: Figures in parentheses are frequencies and those out of parentheses are percentages

3.2.4 Impacts on Local Income and Household Benefits

3.2.4.1 Perceptions on local incomes and employment from household heads

Based on responses obtained from interviews with household heads, Fig. 10 presents an illustration of the contributions of companies to household incomes in their operational areas. It can be observed in Fig. 10 that average monthly incomes are higher in mining localities (SLL 1, 482,240) relative to those in MAC communities (SLL 501,200). It should be noted, however, that both mining and MAC activities have not created much jobs in their areas. Table 24 presents the contributions of companies to employment in their host communities.

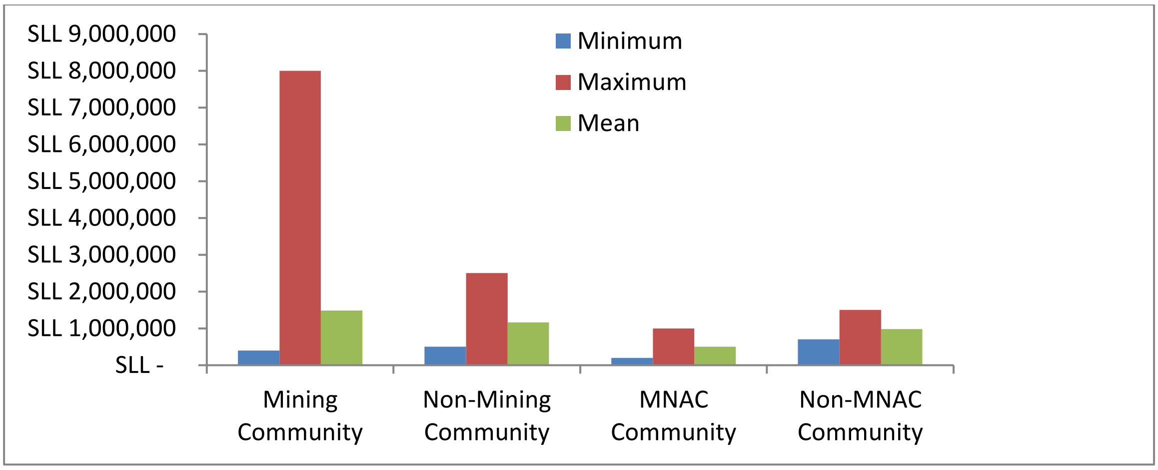


Figure 10 Contributions of companies to monthly household incomes in their operational areas.

In Moyamba, 73.1% and 75% of households in mining and non-mining areas, respectively had members working in the mines. In Pujehun, 33.3%, 81% and 66.7% of households in mining, MAC and non-MAC/mining areas, respectively had members employed in MACs. This indicates that MAC communities benefit more from company jobs than other localities.

On the mainstay of households, no significant ($p > 0.05$) difference is observed between districts. In Moyamba, 69.2% and 75.0% of respondents in mining and non-mining areas, respectively reported company jobs as their primary source of household income. In Pujehun, 33.3%, 76.2% and 66.7% of the respondents in mining, MAC and non-MAC/non-mining localities, respectively, indicated company jobs as their primary source of household income. This also implies that MAC communities depend more on company jobs than other localities.

Table 24 Perceptions of household heads on companies' contributions to employment and income.

Variables	Community Type						
	Moyamba			Pujehun			
	Mining community	Non-mining community	P-Value	Mining community	MAC community	Non-mining/non-MAC	P-Value
Do indigenes benefit from employment?			0.001*				0.027*
Yes	36.0(49)	17.0(23)		20.0(5)	36.7(33)	20.7(24)	
No	64.0(87)	82.6(109)		80.0(20)	63.3(57)	79.3(92)	
Do household members work for companies?			0.001*				0.000*
Yes	19.1(26)	6.1(8)		12.0(3)	23.3(21)	2.6(3)	
No	80.9(110)	93.9(124)		88.0(22)	76.7(69)	97.4(113)	
Is household primary income from company jobs?			0.754^{ns}				0.311^{ns}
Yes	69.2(18)	75.0(6)		33.3(1)	76.2(16)	69.2(18)	
No	30.8(8)	25.0(2)		66.7(2)	23.8(5)	30.8(8)	
If yes, what type of employment?			0.914^{ns}				0.055^{ns}
Direct	73.1(19)	75.0(6)		33.3(1)	81.0(17)	73.1(19)	
Indirect	26.9(7)	25.0(2)		33.3(1)	19.0(4)	26.9(7)	
Both	0.0(0)	0.0(0)		33.3(1)	0.0(0)	0.0(0)	

***Source**: LDA Field Survey Data, 2020*

: Test statistics significant (P<0.05)* ***ns= Test statistics non-significant (P>0.05)*

***NB:** Figures in parentheses are frequencies and those out of parentheses are percentages*

3.2.4.2 Perceptions on local income and employment from key informants

Table 25 presents perceptions obtained from key informants on the contribution of mining and MAC activities on employment in their communities of operation. In Moyamba, 8.1% and 14.3% of key informants in mining and non-mining areas, respectively, stated that their community benefited from company employment. In Pujehun, 40%, 26.1% and 32.3% of the key informants in the mining, MAC and non-mining/non-MAC communities reported that their community benefited from company jobs, respectively. From key informant interviews, 66.7% and 50.0% of the participants in MAC and non-MAC/non-mining areas, respectively, indicated that indigenes are generally given priority during company employment processes.

Table 25 Perceptions of key informants on company contributions to employment and income.

Variables	Community Type				
	Moyamba		Pujehun		
	Mining community	Non-mining community	Mining community	MAC community	Non-mining/non-MAC
Do indigenes benefit from employment?					
Yes	8.1 (3)	14.3 (5)	40.0 (2)	26.1 (6)	32.3 (10)
No	91.9 (34)	85.7 (30)	60.0 (3)	73.9 (17)	67.7 (21)
Are indigenes given priority in employment?					
Yes	0.0 (0)	40.0 (2)	100 (2)	66.7 (4)	50.0 (5)
No	100 (3)	60.0 (3)	0.0 (0)	33.3 (2)	50.0 (5)
Main beneficiaries of employment					
Adults male	0.0 (0)	20.0 (1)	50.0 (1)	66.7 (4)	20.0 (2)
Youths	100 (3)	80.0 (4)	50.0 (1)	33.3 (2)	70. 0 (7)
Everybody	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	10.0 (1)

***Source**: LDA Field Survey Data, 2020*

***NB:** Figures in parentheses are frequencies and those out of parentheses are percentages*

3.2.4.3 Perceptions on company employment from focus group discussions

From the focus group discussions, it was recorded that jobs provided by companies are not sufficient to cushion the effect of land degradation or dispossession which has cost a good number of indigenes their livelihoods from agriculture. The few people employed by these mining and MACs reported poor salaries which cannot sustain their families or dependants. Some claimed that the better paying jobs are mostly reserved for people from outside their communities while they are mostly given labour-intensive jobs with no legally binding contracts. Respondents therefore called for jobs with better salaries and conditions of service.

3.2.2 Impacts on Household Livelihoods

Figure 11 presents the contributions of mining and MACs to household livelihoods. In the mining areas of Moyamba, 3.7% of the respondents attributed livelihood improvement to company jobs, while none of the respondents in the non-mining areas made such views. In Pujehun, 8%, 13.3% and 3.4% of the respondents in the mining, MAC and non-mining/non-MAC areas, respectively attributed livelihood improvement to company jobs. This implies that MACs are more perceived to contribute to livelihoods than mining companies. It should be noted, however, that mining communities have more access to land than MAC localities like Malen. Therefore, livelihoods can be more dependent on company jobs in MAC areas.

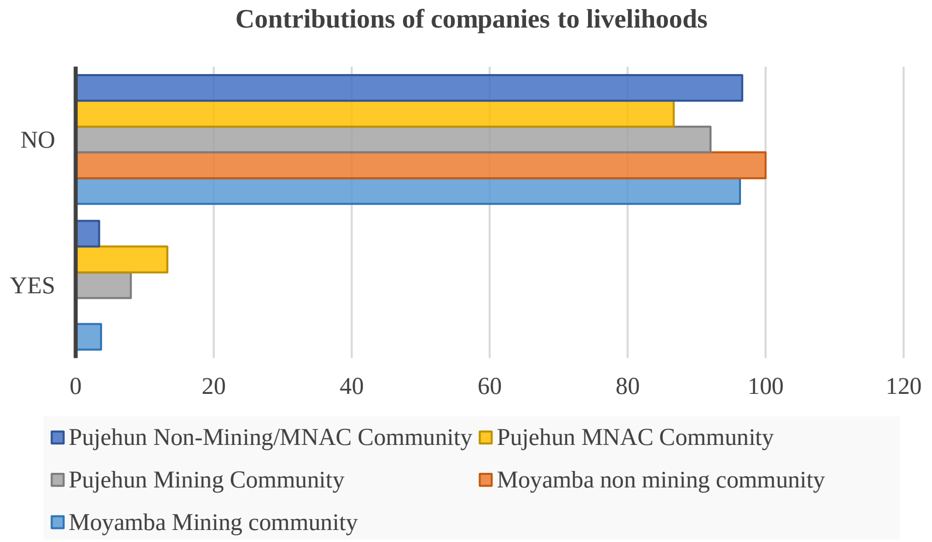


Figure 11 Contributions of companies to household livelihoods (Yes or No).

***Source**: LDA Field Survey Data, 2020*

Figure 12 presents the types of company contributions to livelihoods, other than employment, health, and infrastructure. In the mining and MAC communities, 18.2% and 13.3% of the respondents, respectively mentioned that their communities have benefited from scholarships and portable water. Another 18.2% of respondents in mining areas and 25% of respondents in MAC areas stated that they had benefited from a ready market for food crops. They claimed that the establishment of companies has created opportunities for business, as demand for crop products has increased as a result of the influx of people into their communities. In the localities where no mining or MAC activities are taking place, 25% of the respondents said that company employees with higher purchasing power buy food stuffs produced by the indigenes of these communities and this has helped to increase their incomes. Few (9.1%) of the respondents in the mining communities indicated a growing market for petty business which is increasingly becoming prominent as an alternative livelihood in the areas surveyed.

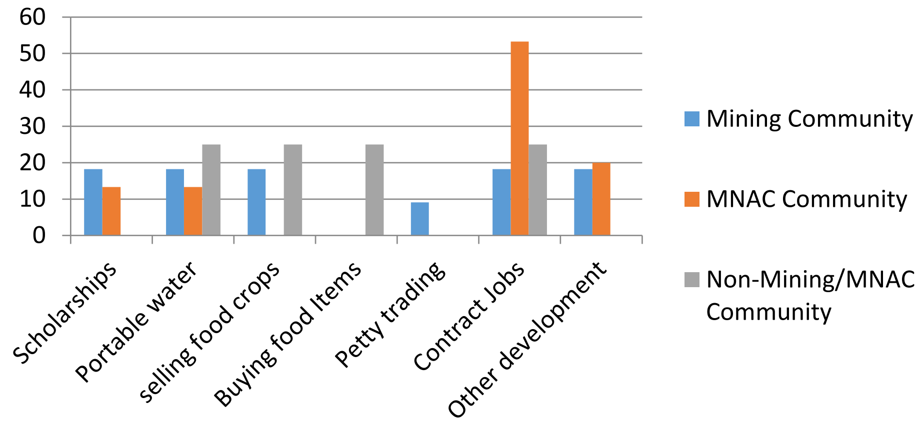


Figure 12 Types of company contributions to household livelihoods.

***Source**: LDA Field Survey Data, 2020*

The category of beneficiaries and types of health facilities provided by companies are shown in Table 26. In the surveyed localities, health benefits from companies are highest (2.9%) in the mining areas and least (1.1%) in the MAC communities. Medical treatment and other health facilities were the mentioned benefits. This implies that contributions of mining and multinational agricultural companies to health facilities in these communities are minimal. The main household beneficiaries of healthcare systems were mostly children (66.7%) and adult females (33.1%) in the mining communities, while in the MAC localities, the main beneficiaries were overwhelmingly adult females. In general, indigenes believed that the operations of mining and MACs would contribute to their socio-economic wellbeing through improvement of health facilities, and provision of scholarships and water supply. At present the locals acknowledge very little benefits from the operations of these companies. This observation is consistent with that made by Ngobese (2015) who reported that community expectations for corporate social responsibilities are higher than what companies can provide.

Based on responses acquired from focus group discussion across the investigated localities, there are generally insufficient health facilities in Lower Banta. The company hospitals only provide services to their staff and indigenes have to travel several miles to access healthcare. In Upper Banta, on the other hand, respondents articulated an improvement in health facilities brought by companies and are accessible by children and lactating mothers. In the same vein, some improvements in the healthcare delivery have been noted in the MAC areas in Pujehun.

Table 26 Perceptions on the contributions of companies to healthcare systems of host communities.

Variables	Community Type		
	Mining community	Non-mining community	MAC community
Community benefit from health facilities?			
Yes	2.9(4)	1.5(2)	1.1(1)
No	94.9(129)	55.3(73)	84.4(76)
Not applicable /Don't know	2.2(3)	43.2(57)	14.4(13)
Type of health facilities provided			
Medical treatment	25.0(1)	50.0(1)	100.0(1)
Others (specify)	75.0(3)	50.0(1)	0.0(0)
Do households benefit from health facilities?			
Yes	75.0(3)	0.0(0)	100.0(1)
No	25.0(1)	100.0(2)	0.0(0)
Main beneficiaries			
Adult females (> 35yrs)	33.3(1)	0.0(0)	100.0(1)
Children (< 18yrs)	66.7(2)	0.0(0)	0.0(0)

Source*: LDA Field Survey Data, 2020*
NB: *Figures in parentheses are frequencies and those out of parentheses are percentages*

3.3 Impacts of Mining and MAC Activities on the Environment

3.3.1 Impacts on the Physical Environment

3.3.1.1 Perceptions on the impacts of mining and MACs on environmental quality

A household analysis was conducted on indigenous perceptions of the environmental impacts of mining companies and MACs using multiple responses and cross tabulations. Out of 161 households interviewed in mining communities, 81.4% (131 households) perceived negative environmental impacts due to the activities of mining companies. In the MAC localities, out of the 72 households interviewed, 56.9% (41 households) perceived negative environmental impacts. This observation thus suggests that the activities of mining companies are more perceived to have negative environmental impacts than those of MACs in the study areas. In households in mining localities the three most notable impacts are loss of farmland (21.1%), pollution of water bodies (21.1%), and soil fertility degradation (20.7%). In MAC localities the most notable impacts include air pollution (26.8%), forest and soil depletion (22.5%), and water pollution (21.0%). Table 27 presents the perceptions of household respondents on the impacts of mining and MAC activities on environmental quality in the localities under study.

Table 27 Household perceptions on environmental quality in mining and MAC localities.

Variables	Community Type			
	Mining community (n=617)	MAC community (n=138)	Total (n=755)	P-Value
Forest degradation	21.1 (130)	22.5 (31)	21.3 (161)	0.000
Soil degradation	20.7 (128)	22.5 (31)	21.1 (159)	0.000
Water pollution	21.1 (130)	21.0 (29)	21.1 (159)	0.000
Air pollution	17.5 (108)	26.8 (37)	19.2 (145)	0.544
Flooding	11.7 (72)	1.4 (2)	9.8 (74)	0.000
Drought/dry spells	7.9 (49)	5.8 (8)	7.5 (57)	0.004

Source: *LDA Field Survey Data, 2020*

: Test statistics significant (P<0.05)* ***ns**= Test statistics non-significant (P>0.05)*

NB: *Figures in parentheses are frequencies and those out of parentheses are percentages*

Results in Table 27 were substantiated by findings obtained from key informant interviews where soil (27.0%) and forest (25.5%) degradation and water pollution (25.5%) were the three most perceived impacts of mining. In MAC communities, loss of forest cover (43.2% of respondents) and air pollution (32.4% of respondents) are the two most perceived impacts.

In general, majority of households in the mining communities perceived water pollution, loss of forest/vegetative cover and soil degradation as the major problems they are facing due to mining operations. Other impacts at less alarming rates are flooding and the occurrence of dry spells (contingent drought) during the rainy season. A decrease in forest cover has the potential to alter the rainfall regime (Mensah *et al*. 2015). The indigenous perceptions on environmental quality recorded in this study resonates well with the findings of Ndomahina (2008) that mining operations have the tendency to degrade forests, and soil and water quality through deforestation, and the deposition of solid and chemical waste into the environment.

3.3.1.2 Perceptions on other environmental impacts of mining and MACs

Other environmental issues of far-reaching social consequences that were highlighted by respondents are loss of farmlands (37.4%), unsuitability of available farmlands (25.2%) and growing unemployment (21.4%) due to the lack of land for farming and other land-uses. In MAC areas, the other impacts that are most perceived by respondents include complete loss of farmlands (58.5%) and unsatisfactory compensation for land dispossession (31.7%). A statistical analysis of the aforementioned factors relative to respondents is given in Table 28.

Table 28 Other perceived impacts of mining and MACs on environment and livelihoods.

Variables	Community Type	
	Mining community (n=161)	MAC community (n=90)
Loss of farmland	37.4 (49)	58.5 (24)
Unsatisfactory compensation	13.7 (18)	31.7 (13)
Indigenes not employed	21.4 (28)	9.8 (4)
Land unsuitable for farming	25.2 (33)	0.0 (0)
Deforestation	2.3 (3)	0.0 (0)

Source*: LDA Field Survey Data, 2020*
NB: *Figures in parentheses are frequencies and those out of parentheses are percentages*

3.3.2 Impacts on the Socio-Cultural Environment

3.3.2.1 Perceived impacts on human health from household interviews

Out of 499 households, 163 (32.7%) households have faced health challenges that are related to the impacts of company activities. The most reported health issues in mining communities are waterborne diseases (27.8%), malaria (26.2%) and airborne diseases (23.8%). Within the MAC areas, malaria (42.5%) is the most frequently reported disease followed by airborne (28.8%) and waterborne (16.4%) diseases. In non-mining and non-MAC areas, the impacts of company activities on human health are little felt. This implies little neighbourhood or spill over effects of the activities of these companies to localities where they are not operational. Perceptions on the most prevalent diseases in the areas under study are provided in Table 29.

Table 29 Household perceptions on the most common diseases associated with company operations.

Variables (diseases)	Community Type				
	Mining community *(n=324)*	MAC community *(n=73)*	Non-company community *(n=5)*	Total *(n=413)*	P-Value
STD	11.1 (36)	6.8 (5)	25.0 (4)	10.9 (45)	0.001*
Malaria	26.2 (85)	42.5 (31)	25.0 (4)	29.1 (120)	0.157^{ns}
Airborne	23.8 (77)	28.8 (21)	25.0 (4)	24.7 (102)	0.135^{ns}
Waterborne	27.8 (90)	16.4 (12)	25.0 (4)	25.7 (106)	0.00*
Other	11.1 (36)	5.5 (4)	0.0 (0)	9.7 (40)	0.246^{ns}

Source*: LDA Field Survey data, 2020*
: Test statistics significant (P<0.05)* ***ns**= Test statistics non-significant (P>0.05)*
NB: *Figures in parentheses are frequencies and those out of parentheses are percentages*

3.3.2.2 Perceptions on human health impacts from focus group discussions

From focus group discussions it was recorded that water bodies proximal to mine sites have become polluted by both solid and chemical waste from mining activities in Lower Banta and Upper Banta. There is also air pollution from the plying of heavy-duty vehicles on the hull roads which releases a huge amount of dust particles into the air especially during the dry season. Local residents have been exposed to respiratory infections, diarrhoea, headaches, eye irritation, and skin rash. Airborne diseases were also reported in MAC communities.

3.3.2.3 Socio-economic impacts of land degradation

Table 30 presents the most notable socio-economic impacts of land degradation as perceived by respondents in the study areas. From a total of 499 households that were interviewed, 195 (39.1%) households indicated that they have been exposed to the impacts of land degradation due to the activities of mining and MACs. In mining communities, the most notable impacts include reduction in the quantity of arable lands (12.9%) for cultivation, increased distance to access farmlands (12.6%) and household food insufficiency (12.1%). In MAC communities, reduction in available land (13.2%), and increased hunger (13.0%) and distance to farmlands (13.0%) were noted. In non-mining/MAC communities, the rate of land degradation is very gradual as it is mostly due to small-scale extractive industries (mining, logging and charcoal).

Table 30 Household perceptions on other impacts of land degradation due to mining and MACs.

Variables	**Community Type**				
	Mining community (n=978)	MAC community (n=476)	Non-company community (n=38)	Total (n=1492)	P-Value
Hunger	12.1 (118)	13.0 (62)	10.5 (4)	12.3 (184)	0.150^{ns}
Reduction in arable lands	12.9 (126)	13.2 (63)	7.9 (3)	12.9 (192)	0.000*
Expensive farm rents	11.0 (108)	9.9 (47)	5.3 (2)	10.5 (157)	0.023*
Hardships as compensations unpaid	10.4 (102)	12.6 (60)	13.2 (5)	11.2 (167)	0.037*
Long distance to available farms	12.6 (123)	13.0 (62)	13.2 (5)	12.7 (190)	0.909^{ns}
Living in abject poverty	10.9 (107)	11.6 (55)	13.2 (5)	11.2 (167)	0.758^{ns}
Unemployment/underemployment	11.0 (108)	12.4 (59)	13.2 (5)	11.5 (172)	0.297^{ns}
Difficulty in educating wards	9.5 (93)	7.8 (37)	13.2 (5)	9.0 (135)	0.092^{ns}
Resettlement	9.5 (93)	6.5 (31)	10.5 (4)	8.6 (128)	0.009*

***Source**: LDA Field Survey Data, 2020*
: Test statistics significant (P<0.05)* ***ns= Test statistics non-significant (P>0.05)*
***NB:** Figures in parentheses are frequencies and those out of parentheses are percentages*

Other perceived socio-economic impacts of land degradation are presented in Table 31. Issues of deforestation (31.3%), theft (27.1%), alcoholism and drug abuse (22.2%) and an increase in prostitution (62.5%) have been reported by household respondents. These socio-economic impacts are also perceived by key informants especially in mining communities.

Table 31 Other perceived socio-economic impacts of mining and MAC activities.

Variables	Community Type				
	Mining community (n=406)	MAC community (n=139)	Non-company community (n=8)	Total (n=553)	P-Value
Deforestation	31.3 (127)	25.9 (36)	37.5 (3)	30.0 (166)	0.000*
Crime (theft)	27.1 (110)	36.0 (50)	0.0 (0)	28.9 (160)	0.000*
Alcohol and drug abuse	22.2 (90)	17.3 (24)	0.0 (0)	20.6 (114)	0.000*
Prostitution	19.5 (79)	20.9 (29)	62.5 (5)	20.4 (113)	0.041*

***Source**: LDA Field Survey Data, 2020*
: Test statistics significant (P<0.05)* ***ns= Test statistics non-significant (P>0.05)*
***NB:** Figures in parentheses are frequencies and those out of parentheses are percentages*

From focus group discussions, forest and soil degradation are the most perceived impacts of mining companies and these have resulted in the loss of vital ecosystems services, flooding, erosion and poor soil fertility. There is an increase in crime rates, especially theft. This the indigenes attributed to the arrival of migrants in search of jobs. Some of the job seekers end up in criminal activities as an alternative in the absence of company jobs. There has also been an increase in prostitution, unwanted pregnancies and early marriage in mining communities.

3.3.2.4 Lack of access to information on land deals and land legislation

Table 32 presents the perceptions of respondents on the accessibility to information on land deals and land legislation. There is generally observed a lack of information on land deals and access to land legislation. In Moyamba, just 27.9% of respondents in mining areas indicated they had access to land information. In MAC communities, 33.3% indicated they had access to land information. The most trusted sources of information on land deals and land legislation are relatives and friends, stakeholder's meetings, and government officials. On the access to information on land legislations, 17.6% and 9.8% of the respondents in mining and MAC areas, respectively, indicated they had access to such information. This implies that there is generally poor access to information and the problem is more serious in MAC areas.

Table 32 Perceptions of household heads on access to information on land deals and negotiations.

Variables	Community Type				
	Moyamba		Pujehun		
	Mining community	Non-mining community	Mining community	MAC community	Non-mining/non-MAC community
Access to information					
Yes	27.9(38)	18.2(24)	4.0(1)	33.3(30)	12.1(14)
No	72.1(98)	81.8(108)	96.0(24)	66.7(60)	87.9(102)
Access to land legislation					
Yes	17.6(24)	9.8(13)	4.0(1)	16.7(15)	11.2(13)
No	82.4(112)	90.2(112)	96.0(24)	83.3(75)	88.8(103)
Landowners involvement in land deals					
Yes	23.5(32)	37.1(49)	76.0(19)	28.9(26)	43.1(50)
No	76.5(104)	62.9(83)	24.0(6)	71.1(64)	56.9(66)
Availability of advocacy organisations					
Yes	22.8(31)	5.3(7)	32.0(8)	47.8(43)	12.9(15)
No	77.2(105)	94.7(125)	68.0(17)	52.2(47)	87.1(101)
Improvement in land deals					
Yes	24.(33)	1.5(2)	8.0(2)	11.1(10)	6.0(7)
No	75.7(103)	98.5(130)	92.0(23)	88.9(80)	94.9(109)

Source: *LDA Field Survey Data, 2020*
NB: *Figures in parentheses are frequencies and those out of parentheses are percentages*

The findings in Table 32 are further substantiated by responses from focus group discussions. There is generally a lack of access to information on the prevailing land tenure system with the advent of companies. Custodians of land information are mostly chiefs and household heads who hardly share such information to the general public. There are no effective platforms for land negotiations and advocacy and women and youths are considered the most marginalised. Land negotiations with companies are poor and there is little implementation of corporate social responsibilities. There is need to review land deals and land-use policies.

Table 33 presents perceptions of key informants on stakeholders' access to information and involvement in land negotiations. In Moyamba, 21.6% and 51.4% of key informants in the mining and non-mining communities, respectively, said landowners are involved in land negotiations with mining companies. Landowner's involvement in land deals was relatively high (60%, 65.2% and 71%, respectively), in mining, MAC, and non-mining communities in Pujehun. Based on respondents' perceptions, there are more land advocacy organisations in Pujehun than in Moyamba. However, access to land legislation is still very poor in Pujehun and this is attributable to the lack of an interface between those organizations and indigenes.

Table 33 Perceptions of key informants on access to information and involvement in land deals.

Variables	**Community Type**				
	Moyamba		Pujehun		
	Mining community	Non-mining community	Mining community	MAC community	Non-mining/non-MAC community
Access to information					
Yes	45.9 (17)	34.3 (12)	60.0 (3)	43.5 (10)	38.7 (12)
No	54.1 (20)	65.7 (23)	40.0 (2)	56.5 (13)	61.3 (19)
Access to land legislation					
Yes	24.3 (9)	28.6 (10)	20.0(1)	43.5 (10)	51.6 (16)
No	75.7 (28)	71.4 (25)	80.0 (4)	56.5 (13)	48.4 (15)
Landowners involvement in land deals					
Yes	21.6 (8)	51.4 (18)	60.0 (3)	65.2 (15)	71.0 (22)
No	78.4 (29)	48.6 (17)	40.0 (2)	34.8 (8)	29.0 (9)
Availability of advocacy organizations					
Yes	18.9 (7)	17.1 (6)	0.0 (0)	60.9 (14)	51.6 (16)
No	81.1 (30)	82.9 (29)	100.0 (5)	39.1 (9)	48.4 (15)

Source: *LDA Field Survey Data, 2020*

NB: Figures in parentheses are frequencies and those out of parentheses are percentages

3.4 Ranking of Opportunities, Issues and Recommendations

3.4.1 Ranking of Opportunities

Several opportunities, that indigenes can benefit from, are associated with the activities of mining and MACs in their communities of operations. However, due to the constraints in delivering or out-scaling some of these opportunities, it is highly desirable to provide a scale of preference for the opportunities that are either mostly needed or easily accessed. In this regard, the perceptions of indigenes were obtained to rank opportunities on a preference scale using the Kendall's coefficient of concordance. Table 34 provides the results obtained from the ranking of opportunities by respondents in localities of mining companies and MACs.

It is observed in Table 34 that the provision of social amenities is the top ranked opportunity except in the MAC communities in Pujehun where it was ranked second. The second most ranked overall is human capital development followed by access to gainful employment.

Table 34 Ranking of opportunities by household heads in mining and MAC communities.

Variables	Community Type and Ranking									
	Moyamba				Pujehun					
	Mining community		Non-mining community		Mining community		MAC community		Non-mining/non-MAC	
	Mean	**§Rank**	**Mean**	**§Rank**	**Mean**	**§Rank**	**Mean**	**§Rank**	**Mean**	**§Rank**
Provision of social amenities	1.43	1	1.90	1	1.20	1	1.42	1	1.51	1
Building human capacity	3.21	3	2.83	3	2.92	3	3.37	3	2.50	2
Access to gainful employment	1.95	2	2.64	2	2.76	2	2.17	2	3.15	3
Creation of an enabling business environment	3.79	4	3.55	4	3.64	4	3.61	4	3.66	4
Increasing financial capacity by contracting local suppliers	4.61	5	4.08	5	4.48	5	4.44	5	4.18	5
P—value	<0.000		<0.000		<0.000		<0.000		<0.000	
Kendall's W[a]	0.683		0.283		0.590		0.579		0.433	

Source*: LDA Field Survey Data, 2020*

*§**Rank**: Kendall's ranking*

: Test statistics not significant (P>0.05)* ***Kendall's W[a]**: Kendall's coefficient of concordance*

The opportunities were ranked differently by the key informants in the various categories but, overall, the most ranked were provision of social amenities, access to gainful employment, and human capital development**.** The Kendall's coefficient of concordance indicates a good degree (0.664) of agreement among the mining communities in Pujehun, a fair degree (0.218) of agreement among the non-mining communities in Moyamba, a poor degree (0.128; 0.106 and 0.073) of agreement among the mining communities in Moyamba, and the MAC and non-mining/MAC localities in Pujehun. The P-value for mining and non-mining in Moyamba and mining and MAC communities in Pujehun were highly significant (<0.000). Table 35 presents the ranking of opportunities by key informants across the four selected chiefdoms.

Table 35 Ranking of opportunities by key informants in mining and MAC communities.

Variables	Community Type and Ranking									
	Moyamba				Pujehun					
	Mining community		Non-mining community		Mining community		MAC community		Non-mining/non-MAC	
	Mean	**§Rank**	**Mean**	**§Rank**	**Mean**	**§Rank**	**Mean**	**§Rank**	**Mean**	**§Rank**
Provision of social amenities	2.62	1	2.00	1	1.40	1	2.78	2	2.45	1
Building human capacity	3.03	4	2.60	2	2.20	2	2.22	1	3.06	4
Access to gainful employment	2.70	3	3.06	3	3.20	3	3.39	4	2.90	2
Creation of an enabling business environment	2.68	2	3.43	4	3.40	4	3.13	3	2.94	3
Increasing financial capacity by contracting local suppliers	3.97	5	3.91	5	4.80	5	3.48	5	3.65	5
P-value	<0.000		<0.000		<0.010		<0.045		<0.058	
Kendall's W^a	0.128		0.218		0.664		0.106		0.073	

***Source**: LDA Field Survey Data, 2020*

*§**Rank**: Kendall's ranking*

: Test statistics not significant (P>0.05)* ***Kendall's W^a: Kendall's coefficient of concordance*

Table 36 presents the ranking of opportunities by key informants (employees) of Socfin and Natural Habitats in Pujehun. Similar to previous rankings, the provision of social amenities, human capital development and access to gainful employment were the topmost ranked opportunities. The Kendall's coefficient of concordance indicated a good degree (0.614) of agreement among employees of Socfin with a P-value that is highly significant (<0.000).

In addition to the above, responses from focus group discussions revealed that youths in Lower Banta perceived the provision of medical facilities and human capital development (scholarship awards) as the most anticipated opportunities from companies in their areas. Their contribution in this regard has however been very insufficient for the beneficiaries. In Upper Banta, there have been improvements in market opportunities, public health services and water supply. There is however a lack of community centres, inadequate schools, and scholarship opportunities are either inadequate or unfairly distributed among beneficiaries.

Table 36 Ranking of opportunities by employees of Socfin and Natural Habitats.

Variables	Community Type and Ranking			
	Pujehun			
	Makpele (NHSL)		Malen (Socfin)	
	Mean	**[§]Rank**	**Mean**	**[§]Rank**
Provision of social amenities	2.20	1	1.70	1
Building human capacity	2.60	2	2.20	2
Access to gainful employment	3.30	3	2.80	3
Creation of an enabling business environment	3.60	5	3.40	4
Increasing financial capacity by contracting local suppliers	3.30	3	4.90	5
P—value	<0.252		<0.000	
Kendall's W[a]	0.134		0.614	

***Source**: LDA Field Survey Data, 2020*
[§]***Rank**: Kendall's ranking*
: Test statistics not significant (P>0.05)* ***Kendall's W[a]: Kendall's coefficient of concordance*

In Malen, corporate social responsibilities have been manifested through the provision of scholarships, foundation seeds to farmers, water wells, fish ponds and public health facilities. In Makpele, Natural Habitats has implemented corporate social responsibilities through the provision of scholarships and learning materials to school-going children, water wells, and rice processing machines and drying floors to aid local farmers in postharvest processing.

3.4.2 Ranking of Issues

Several issues have been identified in this study. For the development of time- and resource-efficient mitigation strategies, there is need to rank issues in an order of importance or priority. Table 37 provides a ranking of issues by household respondents in the study areas.

In the mining communities in Moyamba, forest/soil degradation is ranked the most alarming issue followed by water pollution and unavailability/insufficient arable land. In the case of Pujehun, the mining community households also ranked forest/soil degradation first, followed by unsuitable/insufficient arable land and water pollution. Unavailability/insufficient arable land are the topmost ranked issues in MAC localities, followed by land disputes and social unrest. The Kendall's coefficient of concordance indicates a moderate degree (0.501) of agreement among the mining households in Moyamba; a fair degree (0.248) of agreement among the mining households in Pujehun and a poor degree (0.181) of agreement among the MAC households in Pujehun. The P-values for all categories are highly significant (<0.000).

Table 37 Ranking of issues by household heads in mining and MAC communities.

Variables	Community Type and Ranking					
	Moyamba		Pujehun			
	Mining community		Non-mining community		MAC community	
	Mean	§Rank	Mean	§Rank	Mean	§Rank
Forest/soil degradation	2.04	1	2.36	1	4.28	4
Unavailable/insufficient arable land	2.73	3	3.00	2	2.77	1
Water pollution	2.62	2	3.64	3	4.94	5
Air pollution	4.36	4	4.12	4	5.03	7
Land dispute	4.87	5	4.76	6	3.02	2
Social unrest	5.80	7	5.44	7	3.46	3
Health issues	5.59	6	4.68	5	4.50	6
P-value	<0.000		<0.000		<0.000	
Kendall's W[a]	0.501		0.248		0.181	

Source: *LDA Field Survey Data, 2020*
§***Rank***: *Kendall's ranking*
*: *Test statistics not significant (P>0.05)* ***Kendall's W[a]***: *Kendall's coefficient of concordance*

Table 38 provides a ranking of issues based on responses from key informants. Forest/soil degradation also appeared as the topmost ranked issue by key informants in all mining areas in Moyamba and Pujehun, followed by unavailability/insufficiency of arable land and water pollution. In the MAC communities, key informants ranked land dispute as the foremost social issue, followed by the unavailability or insufficiency of arable land, and air pollution.

Table 38 Ranking of issues by key informants in mining and MAC communities.

Variables	Community Type and Ranking					
	Moyamba		Pujehun			
	Mining community		Mining community		MAC community	
	Mean	§Rank	Mean	§Rank	Mean	§Rank
Forest/soil degradation	2.27	1	2.00	1	2.26	4
Unavailable/insufficient arable land	2.59	2	2.80	2	2.52	2
Water pollution	2.68	3	3.40	3	5.04	6
Air pollution	4.30	4	4.40	4	4.00	3
Land dispute	5.35	6	4.80	5	4.22	1
Social unrest	6.08	7	5.20	6	4.61	5
Health issues	4.73	5	5.40	7	5.35	7
P-value	<0.000		<0.098		<0.000	
Kendall's W[a]	0.482		0.357		0.305	

Source: *LDA Field Survey Data, 2020*
§***Rank***: *Kendall's ranking*
*: *Test statistics not significant (P>0.05)* ***Kendall's W[a]***: *Kendall's coefficient of concordance*

The Kendall's coefficient of concordance indicated a moderate degree (0.482) of agreement among the mining households in Moyamba; and a fair degree (0.357 and 0.305) of agreement among the mining/MAC localities in Pujehun. The P-values are highly significant (<0.000).

3.4.3 Ranking of Recommendations

In view of the need to realise the opportunities and address the issues ranked by respondents, recommendations that would inform policy actions are highly desirable. Table 39 presents a ranking of recommendations by household respondents in both mining and MAC localities.

In the mining communities in the Moyamba District, the provision of social amenities was the topmost ranked recommendation, followed by the improvement in company employment opportunities for indigenes and more community engagement and improvement in future land negotiations. Mining communities in the Pujehun District suggested the provision of social amenities, financial and input support to farming households, and increasing the quota of indigenes in employment. The recommendations made by the MAC communities ranked the provision of social amenities as the topmost priority, followed by financial and input support to farming households and favourable compensation or surface rent payment for their lands.

Table 39 Ranking of recommendations by household heads in mining and MAC communities.

Variables	**Community Type and Ranking**					
	Moyamba		**Pujehun**			
	Mining community		Mining community		MAC community	
	%	**Rank**	**%**	**Rank**	**%**	**Rank**
Financial and inputs support to farmers	11.8	4	13.6	2	17.0	2
Building human capacity	3.7		7.6	5	4.6	5
Community engagement/improvement in land deals	12.1	3	4.5		6.0	4
Provision of business opportunities	0.6		0.0		0.0	
Increase in the employment quota of indigenes	17.7	2	10.6	3	4.6	5
Favourable compensation/surface rent payment	5.6		1.5		12.4	3
Fulfilment of cooperate social responsibilities	8.5	5	9.1	4	8.3	
Good environmental policy	0.8		0.0		0.0	
Provision of social amenities	36.6	1	51.5	1	45.9	1
Government supervision	2.5		1.5		1.4	

Source*: LDA Field Survey Data, 2020*
Rank*: Ranking of recommendations* ***%:*** *Percentages*

Table 40 presents a ranking of recommendations by key informants. In mining communities in Moyamba and Pujehun, the provision of social amenities was ranked first, followed by the increase in the employment quota for indigenes and financial and input support to farming households. A similar ranking was obtained for the MAC communities in Pujehun District, but in addition, enhanced community engagement in future land deals was recommended.

Table 40 Ranking of recommendations by key informants in mining and MAC communities.

Variables	**Community Type and Ranking**					
	Moyamba		**Pujehun**			
	Mining community		Mining community		MAC community	
	%	**Rank**	**%**	**Rank**	**%**	**Rank**
Financial and inputs support to farmers	6.2	3	15.4	2	7.8	
Building human capacity	4.1		7.7		9.4	3
Community engagement/improvement in land deals	5.2		7.7		9.4	3
Provision business opportunities	0.0		0.0		0.0	
Increase the employment quota of indigenes	23.7	2	15.4	2	29.7	2
Favourable compensation/surface rent payment	5.2		0.0		7.8	
Fulfilment of cooperate social responsibilities	1.0		7.7		1.6	
Good environmental policy	5.2		0.0		3.1	
Provision of social amenities	49.5	1	46.2	1	31.3	1
Government supervision	0.0		0.0		0.0	

***Source**: LDA Field Survey Data, 2020*

***Rank**: Ranking of recommendations* ***%:** Percentages*

CHAPTER FOUR

4.0 Biophysical Impact Assessment and Mapping

This chapter presents detailed empirical evidence of land degradation in the communities under investigation to support, or otherwise, the indigenous perceptions of local inhabitants.

4.1 Soil Degradation

From the socio-economic surveys, inhabitants have perceived significant reductions in soil quality due to human activities, especially mining and deforestation. Available arable lands have either been acquired by mining and Multinational Agricultural Companies (MACs) or of low soil fertility, and thus unsuitable for crop cultivation. To identify the extent to which soils have been degraded, soil physico-chemical properties including potential of hydrogen (pH), electrical conductivity (EC), organic carbon (org C), total nitrogen (tN), total phosphorus (tP), exchangeable potassium (Exc K), exchangeable magnesium (Exc Mg), total iron (tFe), arsenic (As), and cadmium (Cd) were analysed in the laboratory using wet chemical methods. Soil analyses were conducted at chiefdom level with respect to the main landcover types.

4.1.1 Soil Quality in Lower Banta Chiefdom

Table 41 presents results obtained from the analysis of soil samples collected, with respect to the land-cover classes of interest, in the Lower Banta Chiefdom of Moyamba District where industrial mining of rutile, bauxite, ilmenite and zircon have been carried out for decades. Comparisons are made with respect to recommendations of Motsara and Roy (2008) and the Food and Agriculture Organization (FAO) on the permissible limits for agricultural soils.

Table 41 Physico-chemical properties of soil samples per land-cover collected over Lower Banta.

Land-cover	pH	EC	Org C	tN	tP	Exc K	Exc Mg	tFe	As	Cd
Wetland	3.94	0.04	1.30	0.09	28.20	23.00	10.20	45.00	2.10	0.00
Forest	4.74	0.04	1.90	0.16	19.15	24.50	7.30	20.25	1.13	0.02
Barren	4.05	0.06	0.20	0.01	4.60	14.33	0.23	36.00	25.83	0.03
Cropland	4.68	0.03	1.00	0.08	14.56	24.40	11.22	13.20	1.38	0.02
Fallow land	4.23	0.07	0.40	0.04	7.10	23.00	2.50	15.00	1.20	0.05
Permissible limits	**6.5-8.5**	**0.4-0.8**	**≥2.5**	**≥0.5**	**≥200**	**≥60**	**≥30**	**≤20**	**≤10**	**≤0.05**

where pH (unitless), EC (dS/cm), Org C and tN (%), and tP, Exc K, Exc Mg, tFe, As, and Cd (mg/kg)

In Table 41 soil properties vary across land-cover. All soil samples at Lower Banta recorded pH values below the suitable range for crops (6.5 – 8.5). Low soil pH (acidic conditions) affects crops by reducing nutrient availability and microbial activities. Generally, soils in Sierra Leone are acidic due to the geologic materials from which they were formed as well as the tropical climatic conditions (high rainfall and temperatures). However, the low pH in wetlands is attributable to mining which exposes the acidic parent materials. Electrical conductivity (EC) is generally low across land-cover types, implying low levels of available nutrients for crops. Nevertheless, samples collected from barren soils in previously mined and active mining areas recorded significantly high EC values as a result of high soluble salts in those areas. Plant nutrients are highest in forests and wetlands due to the accumulation or deposition of organic matter. However, nutrients levels are generally low across land-cover types and this is of serious concern for agriculture. Soils obtained from barren land, including mine tailings, are the most nutrient depleted. These areas are therefore unsuitable for crop cultivation. Heavy metal (Fe, As, and Cd) contaminants recorded higher concentrations in barren and wetlands. It should be noted that mining leaves behind large, excavated surfaces that remain barren for prolonged periods. Adjacent wetlands are continually polluted by the effluents discharged from processing plants and tailings (Kitula 2006). The accumulation of these metals can pose serious human health implications as they have been linked to diseases.

4.1.2 Soil Quality in Upper Banta Chiefdom

Table 42 presents results obtained from the analysis of soil samples collected over the Upper Banta Chiefdom in Moyamba where rutile, bauxite, ilmenite and zircon are also being mined. Similar to Lower Banta, acidic soil conditions are also observed in Upper Banta, although the wetlands of the latter are on average less acidic. However, EC is alarmingly high in wetlands of Upper Banta and this is attributable to the deposition of highly soluble salts associated with acid-sulphate conditions. High EC values hinders nutrient uptake by plants due to the increase in the osmotic pressure of the nutrient solution and this is of serious concern in the agriculture sector. Soil nutrients are generally low across the study areas and concentrations of heavy metals are alarming in wetlands and barren lands that have been affected by mining.

Table 42 Physico-chemical properties of soil samples per land-cover collected over Upper Banta.

Land-cover	pH	EC	Org C	tN	tP	Exc K	Exc Mg	tFe	As	Cd
Wetland	6.43	2.18	0.93	0.06	22.73	39.67	5.27	52.67	20.83	0.03
Forest	4.97	0.03	0.57	0.04	13.83	30.00	6.40	23.33	1.20	0.04
Barren	3.36	0.06	0.40	0.03	1.10	20.00	3.80	34.00	0.80	0.04
Cropland	4.54	0.03	1.03	0.08	16.03	24.67	5.57	15.67	1.10	0.01
Fallow land	4.01	0.03	1.10	0.10	28.30	28.00	6.70	11.00	0.90	0.00
Permissible limits	**6.5-8.5**	**0.4-0.8**	**≥2.5**	**≥0.5**	**≥200**	**≥60**	**≥30**	**≤20**	**≤10**	**≤0.05**

where pH (unitless), EC (dS/cm), Org C and tN (%), and tP, Exc K, Exc Mg, tFe, As, and Cd (mg/kg)

4.1.3 Soil Quality in Malen Chiefdom

Results obtained from the analysis of soil samples obtained from the Malen Chiefdom in the Pujehun District, where oil palm plantations are becoming dominant, are given in Table 43.

Table 43 Physico-chemical properties of soil samples per land-cover collected over Malen.

Land-cover	pH	EC	Org C	tN	tP	Exc K	Exc Mg	tFe	As	Cd
Wetland	4.70	0.02	1.13	0.08	30.77	35.00	9.03	53.00	1.17	0.04
Forest	5.44	0.02	0.93	0.06	17.10	24.00	12.07	24.67	1.00	0.03
Barren	3.01	0.04	0.07	0.04	5.23	17.00	3.70	13.00	0.90	0.02
Cropland	5.03	0.03	0.80	0.06	17.90	22.50	4.25	17.50	1.25	0.03
Fallow land	4.61	0.04	0.90	0.08	17.90	20.50	4.05	11.50	1.30	0.03
Permissible limits	**6.5-8.5**	**0.4-0.8**	**≥2.5**	**≥0.5**	**≥200**	**≥60**	**≥30**	**≤20**	**≤10**	**≤0.05**

where pH (unitless), EC (dS/cm), Org C and tN (%), and tP, Exc K, Exc Mg, tFe, As, and Cd (mg/kg)

It is observed in Table 43 that similar to the preceding study areas, soils are generally acidic across all land-cover types in Malen. EC values and nutrient contents are also outside the range that is optimal for crop cultivation. Iron toxicity is extremely high in wetlands and this impairs plant cellular structures and physiological processes which results in crop failure. With the application of fertilizers in oil palm plantations, heavy metal (Cd) contaminants are likely to accumulate and become deposited downstream where they can interact with humans.

4.1.4 Soil Quality in Makpele Chiefdom

Table 44 presents results obtained from the analysis of soil samples collected in the Makpele Chiefdom of Pujehun District where there is a gradual expansion of the oil palm planted area.

Table 44 Physico-chemical properties of soil samples per land-cover collected over Makpele.

Land-cover	pH	EC	Org C	tN	tP	Exc K	Ex Mg	tFe	As	Cd
Wetland	3.82	0.05	1.40	0.11	33.65	39.00	8.30	46.50	1.25	0.002
Forest	5.21	0.05	1.81	0.15	34.89	24.88	13.45	23.25	1.30	0.001
Barren	3.71	0.03	0.73	0.05	7.00	17.50	3.52	11.00	0.80	0.001
Cropland	4.60	0.04	0.80	0.06	18.00	19.50	4.85	12.50	1.10	0.003
Fallow land	4.52	0.04	1.00	0.08	28.05	22.00	4.80	11.00	0.90	0.001
Permissible limits	**6.5-8.5**	**0.4-0.8**	**≥2.5**	**≥0.5**	**≥200**	**≥60**	**≥30**	**≤20**	**≤10**	**≤0.05**

where pH (unitless), EC (dS/cm), Org C and tN (%), and tP, Exc K, Exc Mg, tFe, As, and Cd (mg/kg)

In Table 44, acidic soil conditions are also observed across all land-cover categories, and this confirms the acidic state of soils in Sierra Leone which is mostly attributable to the mineral composition of the parent materials and tropical climate conditions across the country. Soil nutrients are generally below optimal levels and Fe toxicity is extremely high in the wetlands. With progressive fertilizer application, there is also the likelihood for cadmium accumulation.

4.2 Water Pollution

Indigenous perceptions obtained from the socio-economic surveys also suggest poor water quality in the areas under investigation, and this they largely attributed to company activities. To validate these perceptions with empirical evidence, the physico-chemical properties of water samples collected over the study areas were analysed to provide an indication of water quality. Using wet chemistry, water samples were analysed for pH, EC, total dissolved solids (TDS), total hardness, nitrates, phosphates, sulphates, tFe, As, Cd, and mercury (Hg). The averages of these parameters were reported relative to the community type in each chiefdom.

4.2.1 Water Quality in Lower Banta

Table 45 presents the average results obtained from the analysis of water samples collected over the Lower Banta Chiefdom. It is seen in Table 45 that, based on established acceptable limits by the World Health Organisation (WHO), water samples collected over mining areas are more contaminated than those in non-mining areas. The pH and EC are higher in mining areas, with TDS, total hardness and sulphates recording extremely high values. Nitrates and phosphates are lower in mining areas and this is attributed to less intensive agricultural activities and therefore a lesser application of fertilizers that could deposit these chemicals. However, there are high levels of tFe, As, Cd and Hg in water samples in mining localities. These metals can be ingested by humans and could have dire health consequences. These provide empirical evidences to indigenous perceptions that water quality is poorer over the mining communities in this chiefdom, thereby making its inhabitant vulnerable to diseases.

Table 45 Physico-chemical properties of water samples collected over Lower Banta.

Parameter	Mining	Non-mining	Acceptable limits
pH (unitless)	5.3	6.3	6.5-7.5
EC (µS/cm)	8.2	1.3	≤2.5
TDS (mg/L)	125	10	≤30
Total Hardness (mg/L)	80	3.2	≤0.6
Nitrates (mg/L)	0.1	1.1	1.0-2.0
Phosphates (mg/L)	0.02	0.06	≤0.05
Sulphates (mg/L)	530	250	≤250
Total Iron (mg/L)	1.2	0.2	≤0.1
Arsenic (µg/L)	1.2	0	≤0.01
Cadmium (µg/L)	2.3	0	≤0.01
Mercury (µg/L)	0.25	0	≤0.05

4.2.2 Water Quality in Upper Banta

Due to the relatively small land area of Upper Banta, water samples in this chiefdom were only collected over mining communities and the averages of each parameter are provided in Table 46. There is on average, poor water quality in Upper Banta relative to acceptable limits. Water samples are on average, acidic, with EC, TDS, total hardness and sulphates all beyond the acceptable limits for human exposure. As in Lower Banta, there are lesser concentrations of phosphates and nitrates but exceedingly high concentrations of tFe, As, Cd and Hg. This also confirms the claims of those who indicated that water quality is poor in Upper Banta.

Table 46 Physico-chemical properties of water samples collected over Upper Banta.

Parameter	Mining	Acceptable limits
pH (unitless)	5.8	6.5-7.5
EC (μS/cm)	8.5	≤2.5
TDS (mg/L)	112	≤30
Total Hardness (mg/L)	63	≤0.6
Nitrates (mg/L)	0.14	1.0-2.0
Phosphates (mg/L)	0.01	≤0.05
Sulphates (mg/L)	510	≤250
Total Iron (mg/L)	1.4	≤0.1
Arsenic (μg/L)	2.1	≤0.01
Cadmium (μg/L)	2.3	≤0.01
Mercury (μg/L)	0.58	≤0.05

4.2.3 Water Quality in Malen and Makpele

Table 47 gives a comparison of the water quality status between the agriculturally intensive areas of Malen Chiefdom and the non-agriculturally intensive areas of Makpele Chiefdom.

Table 47 Physico-chemical properties of water samples collected over Malen and Makpele.

Parameter	Malen (MAC)	Makpele (Non-MAC)	Acceptable limits
pH (unitless)	6.3	6.7	6.5-7.5
EC (μS/cm)	1.2	1	≤2.5
TDS (mg/L)	10	10	≤30
Total Hardness (mg/L)	0.8	0.4	≤0.6
Nitrates (mg/L)	0.21	0.11	1.0-2.0
Phosphates (mg/L)	0.08	0.06	≤0.05
Sulphates (mg/L)	320	125	≤250
Total Iron (mg/L)	0.3	0.2	≤0.1
Arsenic (μg/L)	0.6	0	≤0.01
Cadmium (μg/L)	0.8	0	≤0.01
Mercury (μg/L)	0.02	0	≤0.05

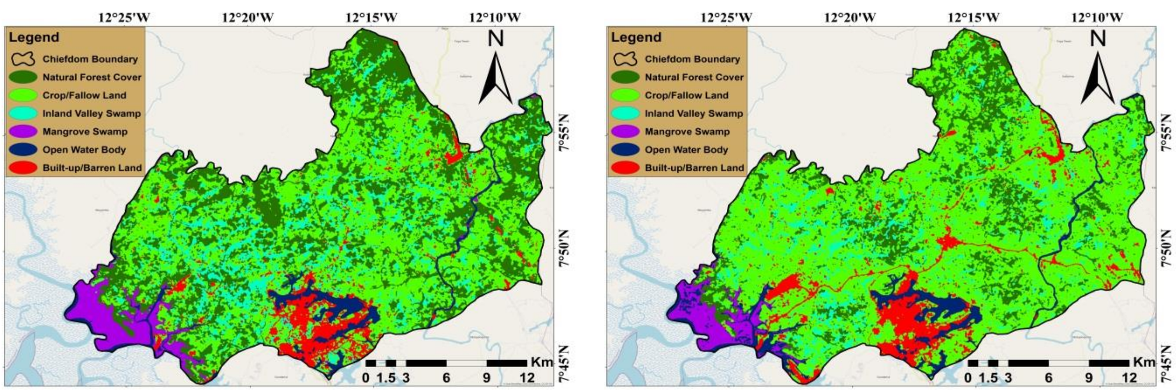
It is observed in Table 47 that EC, TDS, nitrates and Hg are within the acceptable limits in both Malen and Makpele. The pH is slightly acidic in Malen but falls within the acceptable limit in Makpele. While total hardness falls within acceptable limits in Makpele, it is slightly higher in Malen. The concentrations of phosphates and sulphates are higher in Malen and this is not unconnected to the repeated use of fertilizers like ammonium sulphate and single-super phosphate, which is a major source of water pollution (Smith and Siciliano 2015). Heavy metal contaminants including tFe, As and Cd are well beyond the acceptable limits in Malen but in negligible amounts in Makpele. In general, water quality in the plantation agriculture intensive area is poorer compared to locations where plantation agriculture is not intensive. It is important to note that from Tables 45 to 47, water quality recorded under intensive mining is poorer than that under intensive agriculture, implying that the negative impacts of mining on environmental quality and human health are worse than those obtained from agriculture.

4.3 Land-cover Change

Land-cover change is one of the most tangible indicators of land degradation. It provides not only the current state of land but also the rate/trend of change over time. In the current study, therefore, land cover of the target chiefdoms was analysed at two time points; 2000 and 2020. The year 2000 was selected as the baseline as it coincides with the end of the civil war and resumption of economic activities, especially the primary sector. The year 2020 provides the most recent information on the land-cover after two decades of post-war economic recovery.

4.3.1 Land-cover Change in Lower Banta

Six land-cover classes including natural forest cover, crop/fallow land, inland valley swamp, mangrove swamp, open water body, and built-up/barren land were mapped at two time points to provide indications of land degradation due to human and/or climatic factors (Fig. 13).



(a) **(b)**

Figure 13 Land-cover maps of Lower Banta; (a) 2000, and (b) 2020.

In Fig. 13, a significant change in the mapped land-cover categories can be observed in the Lower Banta Chiefdom from 2000 to 2020. This change is presented graphically in Fig. 14.

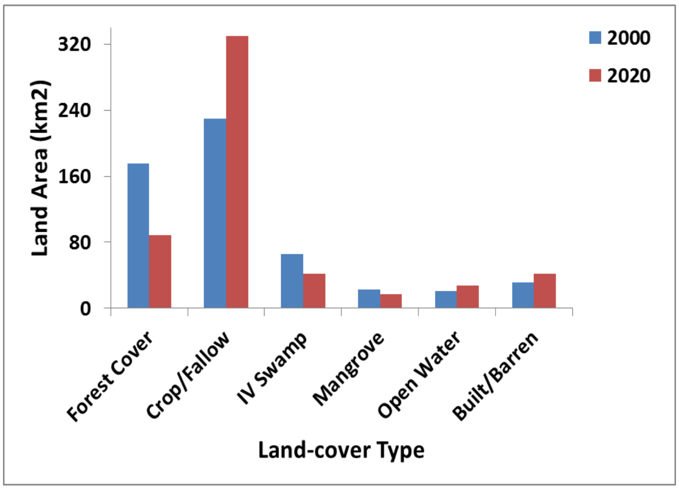


Figure 14 Statistics of land-cover change in Lower Banta Chiefdom between 2000 and 2020.

There is observed a substantial reduction in forest cover (49.5%), an increase in crop/fallow land (43.4%), a decrease in inland valley swamp (35.9%), a decrease in mangrove swamp (25.5%), an increase in open water (29.8%) and an increase in the built/barren land (33.4%). The reduction in natural forest cover that has been mapped in this study supports indigenous perceptions on forest cover loss over the years. Crop/fallow land has taken over much of the previously forested areas due to the combined impacts of mining, farming and logging. The reduction in the inland valley swamp area is alarming and this is attributable to the combined impacts of deforestation and global warming which increases the rate of wetland degradation, and this is supported by a body of literature (Withey and Kooten 2011; Lee et al. 2015). The reduction in the area of mangroves is attributable to the growing use of these plants as fuel wood. The increase in the open water body cannot be unconnected to the dredge (wet) mining practiced by Sierra Rutile which leaves behind vast areas of artificial lakes. The built/barren land-cover has increased in tandem with human settle expansion, and the excavation of land surfaces for mining and road construction. All these point to the fact that there is rapid land degradation in the Lower Banta Chiefdom due to both anthropogenic and climatic influences.

4.3.2 Land-cover Change in Upper Banta

In the Upper Banta Chiefdom, with the exception of mangroves, all land-cover categories investigated in Lower Banta were mapped and analysed over the two time points (Fig. 15). From visual interpretation of the resultant thematic maps, it is very obvious that significant changes in the land-cover categories have taken place in this area over the past two decades.

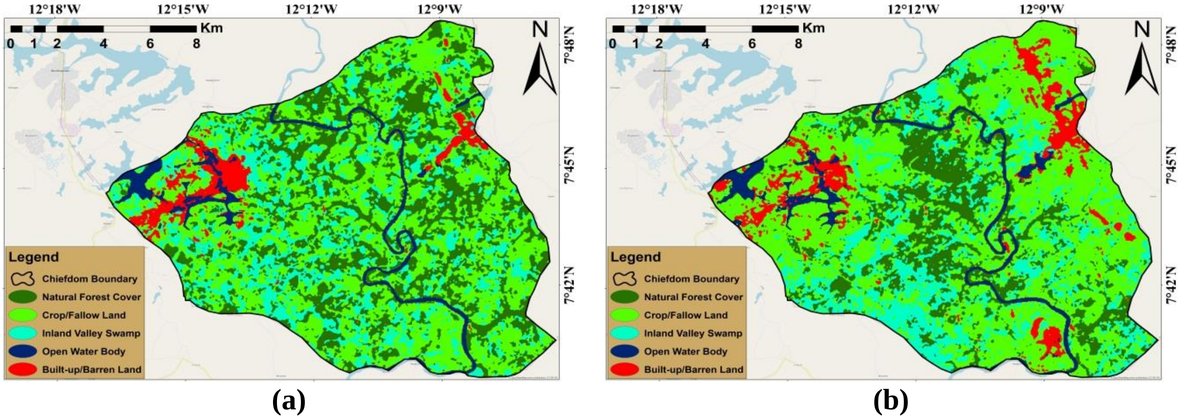


Figure 15 Land-cover maps of Upper Banta Chiefdom; (a) 2000, and (b) 2020.

Figure 16 presents a statistical illustration of the rate of land-cover change in Upper Banta.

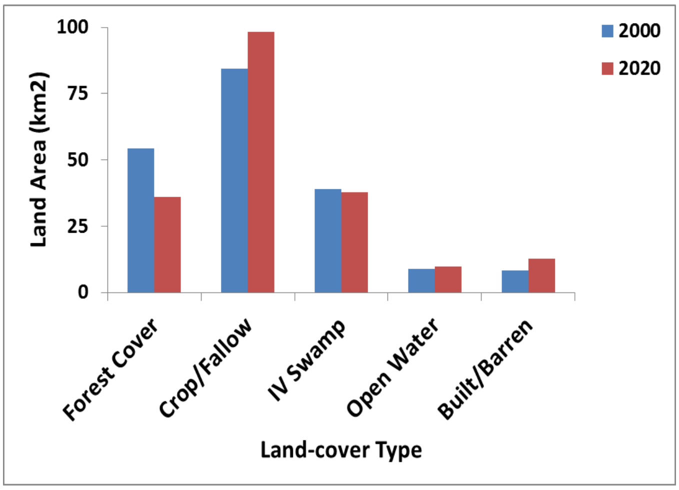


Figure 16 Statistics of land-cover change in the Upper Banta Chiefdom.

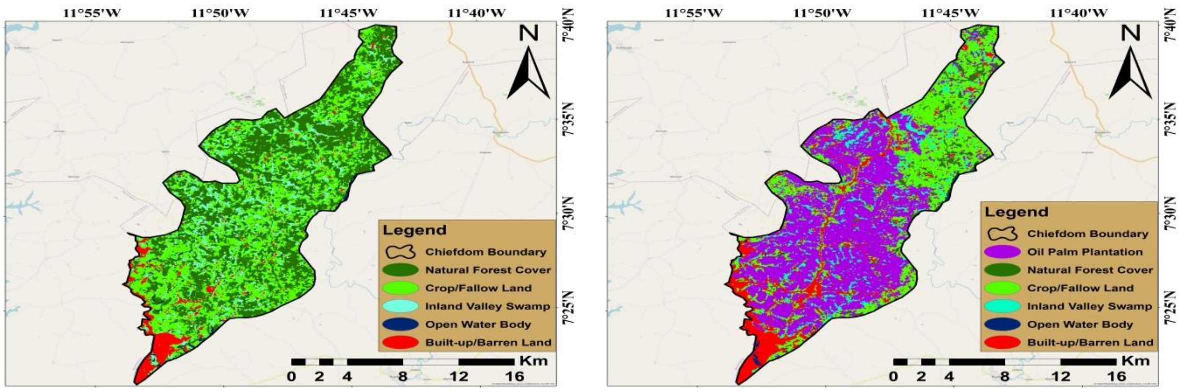
Marked changes in land-cover can be observed in Upper Banta with a 33.5% reduction in forest cover, a 16.7% increase in the crop/fallow land, a 3.4% decrease in inland valley swamp, an 8.5% increase in open water body, and a 56.4% increase in the built/barren land. Being neighbouring chiefdoms with similar socio-economic settings, the same factors that have been attributed to the land-cover change recorded in Lower Banta are also apparent in Upper Banta.

However, forest and inland valley swamp degradation, and expansion in open water are less prominent in Upper Banta. On the other hand, the expansion in the built/barren land is more obvious in Upper Banta and this can be explained by its faster urbanization rate amidst a growing shift from wet to dry mining which leaves vast expanses of excavated land.

4.3.3 Land-cover Change in Malen

The same land-cover classes mapped in Upper Banta were investigated in Malen at 2000, but in 2020, the class oil palm plantation was added to capture the impacts of Socfin operations.

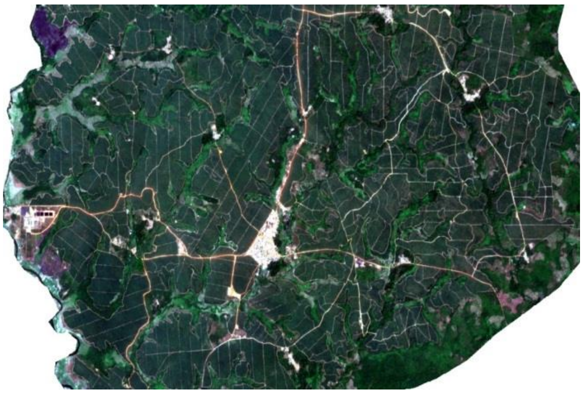
Figure 17 presents the land-cover maps of Malen at 2000 and 2020. Similar to the preceding chiefdoms, vast changes in land-cover have also been detected in this agricultural landscape.



(a) **(b)**

Figure 17 Land-cover maps of Malen Chiefdom; (a) 2000, and (b) 2020.

The oil palm plantation was not mapped at 2000 as this category was not obvious in the corresponding satellites images, especially in the absence of reliable ground-truth data to train the classification algorithm. Hence, oil palm plantation was only mapped at 2020 due to the very obvious conversion of forest cover and crop/fallow land to oil palm plantations and the availability of corresponding ground reference data. It can be observed in Fig. 17 that vast expanses of lands that were originally occupied by forests and crops cultivated by indigenes have now been converted to oil palm plantations. The area occupied by oil palm trees in Malen as mapped in this study is approximately 138 km^2, which is 50% of the entire land area (276 km^2) of the chiefdom. Although wild oil palm trees and smallholder oil palm plantations are also found in this area, majority of the oil palm trees can be accounted for by the Socfin oil palm estates. This can be proven by a raw Sentinel-2 image (Fig. 18), acquired in 2019, from which the organised pattern of the Socfin oil palm plantations can be discerned, thus, demonstrating in real spatial terms, the extent to which indigenes have been deprived of their agricultural land as articulated by the socio-economic data obtained in the current study.



(a) **(b)**

Figure 18 Natural colour Sentinel-2B images of Malen Chiefdom; (a) upper half, and (b) lower half.

A graphical illustration of land-cover change in Malen in the past 20 years is given in Fig. 19.

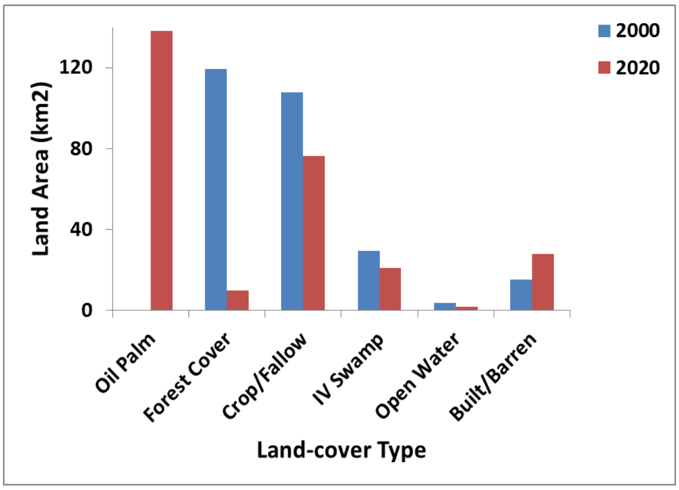
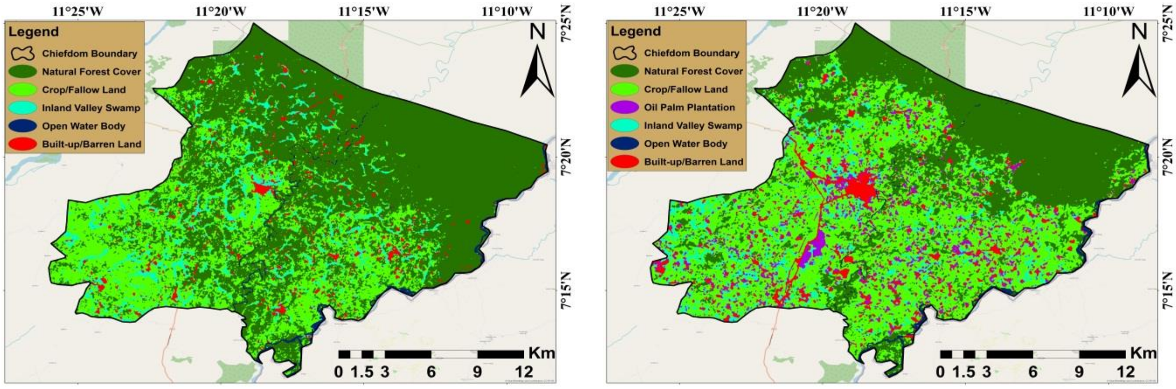


Figure 19 Statistics of land-cover change in Malen between 2000 and 2020.

It can be observed in Fig. 19 that forest cover declined by 91.7%, crop/fallow land declined by 28.9%, inland valley swamp declined by 27.9%, open water declined by 59.1%, and built/barren increased by 84.6%. A significant proportion of forest and crop/fallow land can be accounted for by the expanding oil palm estates. The decline in the area of inland valley swamp is attributable to not only the depletion of wetlands amidst a changing climate but also deforestation which increases evaporation, erosion from uplands and subsequent siltation of adjacent swamps. The rate of expansion of the built/barren land-cover can be explained by artisanal mining, settlement expansion and road constriction especially in the oil palm estates.

4.3.4 Land-cover Change in Makpele

Being of similar socio-economic and environmental settings, the land-cover types mapped in Malen were also used to provide maps of land-cover change in Makpele as given in Fig. 20.



(a) (b)

Figure 20 Land-cover maps of Makpele; (a) 2000, and (b) 2020.

Figure 21 provides a statistical representation of land-cover change in Makpele since 2000.

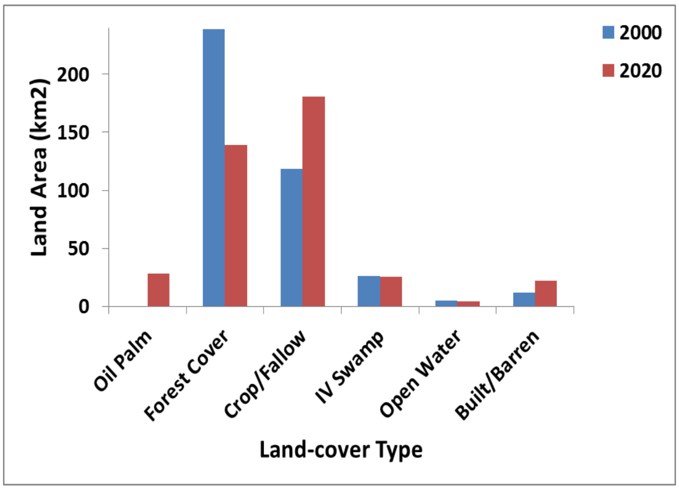


Figure 21 Statistics of land-cover change in Makpele between 2000 and 2020.

The area of oil palm, combining the wild oil palm, smallholder oil palm plantations and oil palm estates of Natural Habitats, is about 28 km^2, and this represents 6.7% of the total land area (418 km^2) of Makpele. Thus, oil palm plantation is far more intensive in Malen than in Makplele. This is proof of the relatively lesser amounts of agriculture related pollutants in the water samples of Makpele. Forest cover declined by 41.7%, crop/fallow increased by 52.7%, inland valley swamp declined by 1.4%, open water declined by 10.4%, and built/barren increased by 84.1%. Much of the forest loss can be accounted for by gains in crop/fallow land.

The slight decline in inland swamp and open water are attributable to the significant presence of forest cover and fallow lands which protect the hydrological regime. The huge expansions recorded in the built-up/barren class are not unconnected to the growth in human settlements across Makpele and land excavation for road construction and artisanal mining.

CHAPTER FIVE

5.0 Comparative Analysis

This chapter presents a comparative analysis between results obtained in the current study and the ESHIA and ESHMP reports of companies in view of national regulatory frameworks.

5.1 Review of National Regulatory Frameworks

5.1.1 Environment Protection Agency

The Environment Protection Agency of Sierra Leone (EPASL) was established by an Act of Parliament in 2008. As the country's environment protection and management arm, EPASL is charged with the responsibility to provide advice on environmental policies: coordinate activities of stakeholders in the environment sector with regards to the flow of environmental information; waste management and improvement of environmental quality; collaborate with foreign partners in the environment sector; issue Environmental Impact Assessment (EIA) licenses and pollution abatement policies; prescribe guidelines on ambient soil, water and air quality; ensure compliance with EIA and environmental management procedures; conduct investigations on the environment to provide advice; ensure awareness on environmental issues; promote effective environmental planning; develop a comprehensive environmental database and ensure the effective dissemination of environmental information; impose and collect environmental protection levies; coordinate and monitor the implementation of all national environmental policies, and act as the country's focal point on environmental issues.

Prior to the issuance of license to projects or companies, an EIA is required as provided for by the First Schedule of the EPASL Act of 2008. An EIA is required for projects whose activities involve substantial conversion of land to agriculture, forestry, lumbering, and fisheries practices; exploitation of water resources; infrastructure and industrial development; mining and quarrying; waste management and disposal; real estate development; and importation of used machinery. However, a number of factors, based on the environmental impact, are considered in determining whether a project requires an EIA, and these factors include: whether the project has or is likely to have substantial impacts on the ecosystem of the locality; the location of the project; whether the project transforms the locality; whether the project results in the diminution of the aesthetic, recreational, scientific, historical, cultural or other environmental quality of the locality; whether the project will endanger any species or flora or fauna or the habitat of the flora or fauna; the scale of the project; the extent of the degradation of the quality of the environment; whether the project will result in an increase in demand for natural resources in the locality; and cumulative impact of the project together with other activities or projects, on the environment. In view of the above factors which take into consideration the social, economic, cultural and natural dimensions of the environment, ESHIAs form the bedrock on which environmental permits are administered.

5.1.2 Mines and Minerals Act

The Mines and Minerals Act of Sierra Leone was passed in Parliament in 2009. This Mines and Minerals Act of 2009 provides policy guidelines on the following aspects: ownership of minerals; acquisition of mineral rights; administration of mineral rights and surface rents; mining registration, records and cadastre; surrender, suspension and cancellation of mineral rights; issuing of licenses (reconnaissance, exploration, artisanal mining, small-scale mining, and large-scale mining); mining of radioactive minerals and dredge mining; environmental protection; community development; and health and safety measures. For the purpose of the comparative analysis, focus is paid to environmental protection and community development.

5.1.2.1 Environmental protection

In deciding whether or not to grant a mineral right, the protection of natural resources in or on the land over which the mineral right is sought, or in or the neighbouring land, should be taken into account. In this regard, an EIA license as prescribed by the EPA Act of 2008 is a prerequisite for granting a small-scale or large-scale mining license. By the Mines and Minerals Act of 2009, holders of mineral rights are required to carry out their operations in an approach that practically minimizes, manages and mitigates any environmental impact resulting from their operations. An EIA prepared by mining companies shall be based on an environmental baseline assessment, and shall contain the type of information and analyses that are reflective of international standards. The EIA shall include the following aspects: a detailed description of the environment, backed by relevant measurements of soil, water and air quality prior to mining operations; a detailed description of project development and operations, reclamation and closure or exit strategy; methodologies and responsible persons or agencies for monitoring potential negative impacts and the effectiveness of mitigation measures; sources of funding for monitoring initiatives; and an Environmental Management Plan (EMP). Applicants or holders of mining licenses are also required to introduce the project to the public and to verify possible impacts as contained in the EIA and to submit an EMP to relevant authorities for approval. Copies of EIA and EMP documents submitted by mining license applicants are made available to the public through the Mining Cadastre Office. To ensure the total adherence to environmental policies, holders of mining license are required to submit annual EMP reports that detail the status of operations, the impacts and the mitigation strategies that have been implemented. The submission of annual EMPs is relevant for determining whether mitigation strategies are successful to inform the renewal of licenses.

5.1.2.2 Community development

Holders of small-scale and large-scale mining licenses are required to assist in the economic development of the host or local communities affected by the impacts of their operations. By the Mines and Minerals Act of 2009, mining companies are expected to promote sustainable development, enhance the general welfare and quality of life of local inhabitants, and shall recognize and respect the rights, customs, traditions, and religion of their host communities. Additionally, holders of mining licenses are required to develop and implement a community development agreement with the primary host community if its mining operations are characterized by the following: extraction of minerals from primary alluvial deposits where throughput exceeds one million cubic meters per annum; underground mining operations where combined run-off-mine ore and waste production is more than one hundred thousand tons per year (waste material not exiting mine mouth not included); open-cast mining operations that extract minerals from primary non-alluvial deposits where combined run-off-mine ore, rock, water and overburden production is more than two hundred and fifty thousand tons per annum; or where the license holder employs or contracts more than one hundred employees or workers at the mine site on a typical working day (including all shifts). By law, holders of mining licenses shall ensure in every year that the community development agreement is in force no less than one percent of the gross revenue amount earned by the mining operations in the previous year to implement the agreement, and an expenditure breakdown of such an amount shall be reported to the Minister of Mines on an annual basis.

The community development agreement shall be negotiated between the mining company and the host community and its contents shall include the following: representatives of the primary host community; objectives of the community development agreement; obligations of the license holder to the community, including socio-economic contributions that will ensure sustainability; obligations of the primary host community to the license holder; means for the review of the community development agreement; consultative and monitoring frameworks between the host community and the license holder, including participation in planning, implementation, management and monitoring of activities carried out under the agreement; and a statement to the effect that any dispute on the agreement shall in the first instance be resolved by consultation, and if the matter remains unresolved, the matter may be brought to the Minister of Mines. Issues to be addressed in the agreement shall include the fulfillment of corporate social and environmental responsibilities during the license period.

5.1.3 National Minerals Agency

The National Minerals Agency (NMA) of Sierra Leone was established by an Act of Parliament in 2012 to promote the development and sustainability of the nation's minerals sector by effectively and efficiently managing the administration and regulation of mineral rights and mineral trading in Sierra Leone. Specifically, NMA is expected to provide technical and other support functions to the minerals sector along the following: conduct geological surveys and other data collection activities; administer and enforce the Mines and Minerals Act of 2009 and any other Act related to mineral trade and regulations; make recommendations for the amendment and improvement in the laws and regulations set in the Mines and Minerals Act of 2009; provide advice on policy matters related to mining and natural resource governance; and formulate and implement plans and systems for managing the responsible development of the overall minerals sector and to promote community rights.

5.1.4 National Water Resources Management Agency

The National Water Resources Management Agency (NWRMA) of Sierra Leone was established by an Act of Parliament in 2017 to ensure that the water resources of the country are controlled in a sustainable manner that takes into account the following: adopting national river basin and aquifer boundaries as the basic units of management of water resources; protecting the water resources for sustainability of the resources and protection of aquatic systems and recognizing the polluter-pays principle; providing for existing customary uses of water and avoidance of significant harm to other users; promoting the efficient and beneficial use of water resources in the public interest; promoting community participation and gender equity in the allocation of water resources; promoting conservation and recognizing the economic value of water resources; reducing and preventing pollution and degradation of water resources; and meeting international obligations in protecting and managing trans-boundary water bodies. As established by the Act, NWRMA shall promote the integrated management of water resources and the coordinated management of: economic development, social welfare and environmental sustainability; land and water resources; the river basin and its adjacent marine and coastal environment; and upstream and downstream interests. The NWRMA Act of 2017 has significant implications for mining and multinational agricultural companies in that: no person shall divert, dam, store, dredge, abstract or use water resources; or construct or maintain any works for water use except in accordance with the provisions of this Act or for the purpose of reasonable domestic and small-scale crop irrigation schemes.

5.2 Review of Company ESHIA Reports

5.2.1 Sierra Rutile Limited

Sierra Rutile Limited (SRL) is a fully owned subsidiary of Iluka Resources and in the past fifty years has been producing high grade rutile, ilmenite and zircon from the world's largest rutile deposit located in the Bonthe and Moyamba districts of southern Sierra Leone. By 2018, SRL had secured seven concessions covering an area of 559 km^2 in the two districts.

Dredge (wet) mining has primarily been carried out by SRL over the past five decades. In 2013, SRL commenced dry (open cast) mining as an auxiliary ore extraction method to the long practiced wet (dredge) mining. In 2016, a second dry mining facility was commissioned, and it is anticipated that in the long run dredge mining will be completely replaced with dry mining in the concessions of SRL. Currently, SRL activities include Lanti mining operations (wet and dry mining), mine processing operations (floating and land-based concentrators), Gangama dry mining operations (dry mining and land-based concentrators), Mineral Separation Plant (MSP), and the transport and export of products through the Nitti Port facility. Moreover, SRL maintains an extensive network of mine (dredge) ponds, and has electricity generation facilities, staff accommodation, office spaces, a clinic and haul roads.

Prior to the resumption of mining activities after the decade-long civil conflict, SRL conducted an Environmental and Social Impact Assessment (ESIA) in 2001, and the ESIA was subsequently updated in 2012. Considering the growing expansion of rutile mining, EPASL issued a notification to SRL for the conduct of a detailed Environmental, Social and Health Impact Assessment (ESHIA) from which to develop an Environmental, Social and Health Management Plan (ESHMP) for their current and proposed wet and dry mining activities, especially for the proposed expansion of SR Area 1. To this end, SRK Consulting (South Africa) was appointed by SRL in 2016 to undertake a scoping site visit from which a scoping report that meets the country's requirements was developed and submitted to, and accepted by, EPASL in October 2017. Subsequently, SRL was requested by Iluka Resources to prepare an ESHIA and ESHMP in accordance with EPASL requirements and Iluka's corporate policies which are aligned with Good International Industry Practice (GIIP). This review critically looks into the 2018 ESHIA and ESHMP reports of SRL to provide an understanding of the biophysical and socio-economic dimensions of the impacts of SRL activities in view of the findings of the current study and national environmental regulations.

5.2.1.1 Impacts on the biophysical environment

From the 2018 ESHIA Report for SRL, there are no indications of toxic elements that would limit plant growth in soils within mining areas. However, previous studies (CEMMATS 2012) have provided evidences of dystrophic leaching with which exchangeable cation sites are predominantly occupied by exchangeable aluminium (Al^{3+} or $Al(OH)^{2+}$), iron and protons (H^{+}) derived from natural organic acids that are associated with decaying organic matter. Under wet conditions, aluminium hydrolysis and equilibration with exchangeable iron and protons results in low pH conditions with a high buffering capacity. In general, soil pH tends to decrease with increasing rainfall and better drainage (Rose et al. 1979). It was confirmed in the study area that better-drained soils recorded low pH values relative to the more poorly drained soils found in the mangrove and swampy areas. Low pH values indicate acidic conditions, implying that soils found inland are generally more acidic than those in wetlands.

Soil nutrients of relevance to plant growth within mining areas were generally considered poor, with potassium, calcium, magnesium and phosphorus being grossly inadequate for plant growth. Additionally, the CEC of soils was investigated. CEC is a measure of the soil's capacity to hold exchangeable cations. It influences the ability of the soil to hold essential nutrients and provides a buffer against soil acidification. Generally, soils found within mining concessions recorded moderate to low CEC values. This is attributable to the generally low clay percentages and highly leached nature of the soils in these areas. Typically, soils rich in organic matter record a higher CEC and thus implying a higher ability to hold soil nutrients.

Surface water quality was assessed to reveal the impacts of mining and processing plants on the water resources of host communities. This is extremely important as majority of local inhabitants depend on open water sources. Water quality data were acquired in July, August and October 2017 and were analyzed by Exova Jones Environmental Laboratory in the United Kingdom. A range of water physical and chemical attributes was analyzed, including all those presented in the preceding chapter. However, differences exist in the units used in expressing element content and the acceptable limits of element content between the ESHIA and the current study. While the ESHIA used the SANS 241:2015 standard limits for portable water, the environment and social regulations for mining (2013) in Sierra Leone and World Bank Guidelines for mining (IFC EHS 2017), this study used the WHO recommendations.

There is generally observed a low water pH with little mineral content for buffering. In this scenario, mineralization and solubilization are expected of some metals, especially aluminum in resident soils, whose occurrence can be natural, and not necessarily due to mining. It should be noted that a low pH with low mineral and salt content may be a natural reflection of the dissolution of carbon dioxide from the atmosphere, respiration of aquatic life forms and the dissolution of natural soil humic acids, and this may not infer a direct impact of mining.

The Mogbwemo Domestic Pond which is a source of domestic water failed to meet water quality guidelines in July and August owing to a pH in the range of 4.2 to 4.7 and elevated concentrations of aluminum. The water quality in this pond was observed to improve slightly in October with a drop in aluminum, though pH was not measured. The drop in aluminum concentration in October can be attributed to a lesser deposition of eroded materials from mining and MSP facilities into the pond as the rains generally subside at this time of the year.

Water discharged from the MSP tailings, through the Mogbwemo Dredge Pond, recorded a pH below legislative limits and aluminum concentrations that exceed drinking water limits. The pH and aluminum concentrations were observed to decrease with distance from the MSP, which implies an impact of effluents from mining activities on the area's surface water.

Downstream of the Bamba/Belebu Pond, the impacts of SRL mining are less obvious, given a slightly acidic condition (pH of 5.8) recorded in August. This was attributed to the lack of active mining activities in this catchment, and thus recording background pH concentrations.

At the old mines of Pejebu, the dam and dredge water quality is comparable to background water quality, although the acidity exceeded the legislative limits, with pH values of 4.5 at the dredge pond and 5.9 at the dam. Thus, the water quality does not fall within legislative limits and drinking water guidelines. At Lanti, pH exceeded the acceptable limit and so are turbidity and concentrations of sulphates, nitrates, manganese, nickel, selenium, zinc and aluminum.

At Gangama, water quality at the G5 dam is comparable to background water quality except for slightly elevated nitrate levels. On the downstream, an acidic pH (5.8) is recorded in tandem with elevated dissolved aluminum. Surface water at Nitti recorded elevated levels of aluminum, chloride, and magnesium. Additionally, there are higher EC (salinity) values and total dissolved solids (TDS) around the Nitti Port area relative to background concentrations.

5.2.1.2 Impacts on the socio-economic environment

It was reported in the ESHIA Report prepared by SRK for SRL in 2018 that migration has led to an increase in the population of host communities of SRL mining activities especially in Moriba and its immediate environs. Overall, 41% of the households indicated the movement of people into their household whereas 35% reported a movement of people out of their households. The main push and pull factors were mainly attributed to job and family matters.

There is an observed drop in senior secondary school enrollment for both boys and girls, but this drop is more pronounced for girls. The poor enrollment of girls is not unconnected to the deep-rooted socio-economic factors that include engagement in peasant farming, teenage pregnancy and early marriage. This is a strong link between education and employment type.

From household interviews, majority of the participants inherited their land from the family line. Some households indicated they had no legal proof of ownership for their land, while others were either renting or occupying land illegally. Inheritance accounted for 43% of land occupation, followed by 'only available land' (24%) and proximity to employment (10%). Interviews further revealed that majority of land occupants were tenants and not landowners.

Portable water was mostly sourced from communal taps, and mechanical and non-mechanical wells. In most cases, however, wells are shallow and easily get dry during the dry season due to inadequate depths. With the drying up of water wells at the dry season, alternative water sources include mine ponds, natural ponds, swamps, rivers, dams and unprotected springs. At the rainy season, water is harvested in small containers rather than in storage tanks. Despite all these challenges, majority of the respondents indicated they had sufficient access to water.

There is little access to electricity in the area, with only Mobinbi and Kpanguma enjoying electricity from the SRL power facility. Wood fulfills the energy needs of most residents for cooking while batteries are the most cited means of generating energy for electricity at night.

Ownership and use of sanitation facilities was observed highest in urban settlements and lowest in villages. Majority of the households interviewed indicated the use of pit latrines while a few others cited open defecation in bushes. Bathing is mostly done in makeshift structures outside homes using buckets and also openly in ponds and freshwater streams.

Local inhabitants in operational areas of SRL suffer from a number of diseases. Based on data obtained from the Moyamba District Council, the top ten diseases in the district include malaria, diarrhea, skin rashes, hypertension, pneumonia, anaemia, intestinal worms, rheumatism, ear infection and onchocerciasis. The prevalence of these diseases has been attributed to the presence of a suitable habitat for their vectors, such as stagnant water as breeding grounds for mosquitos, poor public sanitation and personal hygiene, poor water quality, poor diets, and poor prevention practices. Overcrowding at homes and public places, especially in the populated towns of Moriba and Mogbwemo, were cited as some of the major predisposing factors to the transmission of communicable diseases in host communities of SRL mining operations. Acute respiratory infections are frequently diagnosed with children presenting at health facilities. According to the District Health Management Team (DHMT), there are also seasonal outbreaks of measles which are largely attributable to suboptimal coverage (about 80% in 2016) of measles vaccines in the communities under investigation.

Tuberculosis (TB) featured as a serious health concern in Moyamba. The DHMT reports indicate that TB cases are on the increase with most being co-infected with the Human Immuno-deficiency Virus (HIV). It is apparent that mining areas are becoming hotspots for HIV and TB co-infections. This is a serious health concern in view of a weak healthcare delivery system to address these issues. In fact only twelve health facilities in the district can effectively diagnose and treat TB infections. The DHMT in Bonthe had reported that indicators on TB detection are lagging and not meeting public health targets. The SRL clinic did not report as much cases of TB, however, reported cases were generally co-infected with HIV. Malaria was reported as the premier cause of morbidity among residents. This was attributed to the poor utilization of insecticide-treated bed nets (ITNs) and environmental risk factors including mosquito breeding grounds like stagnant water and dense vegetation. Typically, malaria was reportedly higher during, and immediately after, the rainy season.

In general, health services in and around SRL areas are grossly inadequate with respect to the demands of an increasing population. The biggest health facility, located in Moriba Town, is too small and offered limited services to cater for the needs of a vulnerable population. The SRL clinic receives and stabilizes all emergency cases irrespective of SRL’s involvement. Cases beyond the capacity of the SRL clinic are normally referred to the Serabu Hospital.

5.2.1.3 Environmental, social and health management plan

The Environmental, Social and Health Management Plan (ESHMP) proposed by SRK Ltd. for implementation by SRL, based on the 2018 ESHIA Report, is summarized in Table 48.

Table 48 Environmental, Social and Health Management Plan (ESHMP) proposed for Sierra Rutile.

Recorded impacts	**Mitigation measures**
Biophysical environment	
Air	
Dust emissions during operational phase	Pave or treat road surfaces for ore delivery; use of dust suppression techniques; dust control during loading by minimizing drop heights and prevention of overloading; routine monitoring of emissions and air quality to determine significant increases in emissions and impacts on populations
Dust emissions during the expansion phase	Apply mitigation strategies as listed above
Dust and gas emissions during decommissioning and closure phase	Demolish all infrastructure and reestablish vegetation on demolition footprints; planting of trees on all areas to be rehabilitated, including borrow pits; rehabilitation of slime dams by the application of liming before establishment of vegetation; rehabilitation of MSP tails in situ
Soils	
Loss of utilizable soil resources (sterilization and erosion)	Minimize the disturbed footprint as much as practically possible; soil replacement and concurrent rehabilitation; proper vehicle maintenance and erosion control; implementation of mine closure plan as deemed necessary
Surface water	
Dams/ponds attenuate flood peaks	Sustainable dam removal to allow natural ecosystem functioning; review reservoir hydrology in line with mine closure recommendations
Decrease in water quality downstream	Formalize and size river diversions as per storm water management plan; construction of silt traps as per storm water management plan
Insufficient water for mining and processing	Update water balance and dam volumes to actual water volumes used in the plant and during mining; provide data on current make-up water requirements; if ponds are to be removed from the MSP area, ensure an alternate water supply to guarantee continuation of processing activities
Socio-economic environment	
Economic	
Loss of (or loss of access) to land, crops and livelihoods	Limit project footprint to minimize physical or economic displacement; design and implementation of GIIP resettlement action plans that are inclusive of livelihood restoration for all new physical displacement
Host community disruption due to the influx of non-local job seekers, employees and business owners	Guide management and on-site behavior of personnel; procurement of goods and services through formal means; apply recruitment as set out in policies; communication of recruitment processes; inform locals about operation timeframes and grievance management; training locals to an employable level; engage local authorities in the management of influx

Contribution to national and regional economic growth	Procure goods and services from local or national suppliers; procure ancillary services for goods purchased overseas such as installation from national companies; increasing local employment to remain a focus area
Improved (water, roads) infrastructure due to SRL investment	Education provision to local businesses and government institutions on road maintenance; regular maintenance of SRL infrastructure; regular briefing sessions with chiefs and sectoral ministries or departments
Dissatisfaction over perceived preferences in investments	Active participation in community development committees; access to grievance management procedures; development of collaboration with NGOs; regular dissemination of development and investment information
Health	
Communicable disease transmission	Develop a communicable disease monitoring strategy and mitigation plan; develop outbreak preparedness and response with the DHMT
Increased incidence of malaria in SRL areas	Perform a malaria indicator study to determine the local burden of the disease; conduct baseline entomology study on the presence of diseases
Increased risk of Sexually Transmitted Diseases (STDs)	Review HIV policy and plan to meet project needs; develop STD prevention strategies; transport planning to reduce trucks overnight in host communities; develop a monitoring system for STD indicators
Emergence of zoonotic diseases due to poor water management	Conduct studies with the Lassa Fever Research Center in Kenema to identify reservoir host in the host community; implement rodent control in accommodation camps; implement effective waste management strategies

5.2.2 Vimetco Sierra Minerals Holdings Limited

Sierra Mineral Holdings Limited (SMHL) is a joint venture known as Vimetco Group that owns license to mine bauxite in five chiefdoms in the Bo, Moyamba and Bonthe districts of southern Sierra Leone. The project setting is divided into two areas: areas of direct environmental and social impacts include mine panels, plant site, haul roads, Nitti Port, Matta Camp and communities within the lease extent; areas of project influence where most of the environmental and social impacts are influenced by project activities either within or outside the lease extent and these include areas outside the lease but linked to the haul roads and portions of those chiefdoms outside the lease. The bauxite exploration and mining concession that has been acquired by Vimetco SMHL covers an area of 321.2 km^2 and is valid till 2032.

As a prerequisite for the continuity of their mining operations after the civil conflict, EPASL requested SMHL in 2012 to conduct an Environmental and Social Impact Assessment (ESIA) of current and future mining operations, and from which an impact management plan can be developed for implementation during the entire lifecycle of the mining project. For this purpose, the Tropical Environmental Design Associates (TEDA) was retained by SMHL to prepare an ESIA in 2012 and whose relevant contents to the LDA Report are reviewed below.

5.2.2.1 Impacts on the biophysical environment

SMHL practices opencast mining that involves the removal of vegetation and overburden (top soil) using bulldozers and excavators, resulting in vegetation loss and alteration of topography and landforms. The use of heavy machinery in mining has also resulted in soil compaction, and with the attendant decrease in infiltration, pools of water can be created after prolonged spells of rainfall. According to the projections presented in the 2012 ESIA Report for SMHL, the anticipated impacts of mining can be long-term, but they are of lesser severity.

Overburden materials and ore stockpiles are susceptible to erosion and subsequent deposition to water bodies. This has the tendency to reduce water quality due to the deposition of waste that could contain toxic substances, and this poses significant heath challenges to host communities. As a result, the 2012 ESIA Report indicated that streams and other water bodies are being monitored at sensitive locations to track the effect of mining on downstream surface water quality. The bauxite washing plant does not require any chemical reagent in ore processing, thus, decant water is expected to meet standards like the IFC effluent discharge guidelines. However, accidental discharge of sludge from mine tailings can increase turbidity, conductivity and inorganic particulate matter in water bodies in the environs of the lease area.

5.2.2.2 Impacts on the socio-economic environment

The expansion of SMHL operations has increased traffic in host communities. The increase in traffic is a serious concern as the roads are concurrently used by other private and public vehicles. There has also been a dramatic increase in commercial bike riding in these routes which poses danger especially during the dry season when a huge amount of dust is deposited into the air. Pedestrians are also at a high risk of accidents with vehicles and motor bikes during this period. SMHL employees and their families have access to the health clinic at the mine site. However, serious cases are often referred to the Serabu Hospital that is located 11 km away from the Gondama site. Heath facilities seem inadequate for the community people in operational areas of SMHL, especially with the mass influx of migrants in search of jobs.

Since the resumption of bauxite mining operations, tremendous migration of people into SMHL operational areas has been recorded, with most migrants either taking up company jobs or engage in petty business given the growing market opportunities brought by mining jobs and the subsequent increase in disposable incomes. The anticipated negative socio-economic impacts attendant with this population growth includes the increase in crime (theft), prostitution and spread of STDs, disruption of cultural values, drug and alcohol abuse, noise, juvenile delinquency, domestic violence, early marriage, and teenage pregnancy. These impacts were envisaged to be long-term and on a wider local level but of moderate severity.

Like most mining projects, SMHL operations are expected to have direct and indirect impacts on gender. Such impacts are related to land tenure, economic activities, early (sometimes forced) marriage, and teenage pregnancy. Land ownership is primarily dictated by men and traditional authorities who are mostly males. This puts men at a greater advantage in the land tenure system, and this compromises the productive potential of women especially in the farming sector. There has been an increase in the cost of living in mining communities. The increase in transportation puts women farmers at a great disadvantage as they have to sell their produce at farm gate prices which are lesser than those they would secure in the open markets. There is an increase in the rate of reported gender discrimination in the job market. Mining jobs are mostly reserved for men and women are left to work on the farms. Teenage pregnancy and early marriage are also on the increase. Surveys conducted in these areas revealed that girls generally drop out of school earlier than their male counterparts. The increase in social functions like disco and video shows is one of the key platforms for youth involvement in immoral sexual activities that lead to teenage pregnancy and early marriage.

5.2.2.3 Environmental and social management plan

The Environmental and Social Management Plan (ESMP) proposed by TEDA Consultancy for implementation by SMHL, based on the ESIA conducted in 2012, is provided in Table 49.

Table 49 Environmental and Social Management Plan (ESMP) proposed for Vimetco SMHL.

Recorded impacts	**Mitigation measures**
Biophysical environment	
Air pollution	Dust suppression in the dry season; use of face masks by workers; use of gaseous control equipment at plant site; apply traffic safety rules and regulations; reduce speed limits; construction of speed bumps in villages along haul roads to minimize peoples' exposure
Soil degradation	Reclaim mined-out lands and stockpile areas; separation of super soil from subsoil during removal; adequate crop suitability works for reclamation of agricultural land; re-vegetation of reclaimed land to avoid erosion; establishment of sediment traps, bunds and where necessary, construction of diversion ditches; regular inspection of reclaimed land; application of rock mulch on unprotected surfaces
Surface water pollution	Stockpiles and overburden should not be placed at nearby water ways; proper storage of fuel, oil and other lubricants; effective

	implementation of tailings management plan; avoid leakages into earth fill dams; diversion of rainwater from tailings storage areas
Socio-economic environment	
Community health and safety	Provision of additional health facilities; provision of health services to all workers; avoid health-related environmental effects
Traffic and road safety	Provide driver safety training to all workers; impose speed limits; proper scheduling of truck traffic along public highways to avoid peak hours; introduction of safety campaigns to host communities
Population movements	Give job preference to host communities; investment in alternative livelihoods like poultry, vegetable gardening; brick making etc.
Gender impacts	Skills training for women and girls dropping out from school; provision of credit facilities for women empowerment in business

5.2.3 Socfin Agricultural Company

The Socfin Agricultural Company (SAC) is a subsidiary of the Belgian corporation, Socfin, an investment holding company operating in diverse sectors including plantations, agro-engineering, banking, finance, and real estate. In 2011, SAC secured 6,500 ha of prime agricultural land for the establishment of rubber and oil palm plantations in the Malen Chiefdom of Pujehun District in southern Sierra Leone. SAC has recorded significant expansions over the years and currently holds a land concession of 18,473 ha within which is an estimated 12,349 ha oil palm plantation. By 2019, the company was operating a 30T/h palm oil mill with two biomass boilers, and a mill capacity of 60T/h is anticipated by 2020. As a statutory requirement for securing an operations license for an investment of this nature and magnitude, an ESHIA was requested from SAC by EPASL in 2011. To this end, STAR Consult, an independent local consultancy firm, was contracted to conduct an ESHIA, from which a workable ESHMP can be developed and implemented by SAC. Like previous literature reviews, the ESHIA and ESHMP reports of SAC are reviewed along the following.

5.2.3.1 Impacts on the biophysical environment

At the time the ESHIA field work was conducted (November 2011), the air was generally observed to be clear. Anthropogenic activities that influenced local air quality were mainly related to the slash and burn agricultural practices of local farmers and vehicular movement. Occasional bush fires, mostly during the dry season, also greatly contribute to the release of particulates and oxides of carbon, sulphur and nitrogen into the atmosphere. With the start of SAC farming operations, an increase in pollution and subsequent reductions in air quality are expected from large-scale land clearing, construction works on roads, processing palm oil plants, offices and residential infrastructure, and vehicles plying on unpaved road networks. Gaseous emissions are also expected to be generated from the palm oil and palm kernel mills.

Land clearing for the establishment of oil palm nurseries and plantation estates will expose the loose top soil to erosion during spells of rain and gusty winds. This will lead to the loss of productive soils and hence soil fertility. The use of heavy earth clearing equipment will, in addition to the above, lead to soil compaction, which compromises soil physical properties.

The increase in runoff due to land clearing will increase the deposition of debris into nearby water sources. Additionally, agro-chemicals will be used in nurseries and plantations. This would lead to the leaching of nitrates and phosphates which are major culprits for surface water eutrophication, posing several environmental, ecological and human health challenges.

5.2.3.2 Impacts on the socio-economic environment

With a long-term plan to acquire 30,000 ha of land, SAC operations will significantly disrupt settlements and livelihoods. There is envisaged, a significant reduction in land available to individuals and households for farming, the mainstay of indigenes in SAC operational areas.

Unemployment is a key socio-economic issue in Sierra Leone with limited job opportunities in every part of the country. In operational areas of SAC, there is an anticipated increase in job opportunities. Various job grades will be created at all stages and phases of the project, including nursery establishment, plantation establishment, mill operation, and marketing. These jobs across the SAC value chain would create alternative livelihoods for inhabitants.

Infrastructural development will be at the core of SAC corporate social responsibilities. This will be expressed in the provision of a more connected road network which would meet community and company needs. Improvement in educational and skills training, community water supply and support to the local healthcare delivery system are also anticipated impacts.

With job creation by SAC operations, local incomes are expected to increase, and this would support local businesses. The multiplier effect will be the attraction of new businesses into the community. With increasing attention gained from the Non-Governmental Organization (NGO) community, more livelihood development initiatives are expected to be implemented.

An increase in the migrant population has been reported in most localities of industrial plantations in Africa. Several social issues are anticipated with the migration of job seekers into SAC localities, and this would include increased pressure on land and available housing, increased pressure on community and social services, increase in the spread of diseases, increase in the incidences of conflict and dispute over resources, and the prevalence of crime.

The healthcare delivery system is envisaged to be overwhelmed with the population increase. Poor waste management and waste discharge into rivers, the main water sources, would pose significant threats to human health. Reservoirs that will be constructed for the supply of irrigation water together with waste water treatment stabilization ponds could, if not handled properly, be major breeding sites for mosquitos, the vectors for malaria. These and several other factors are expected to pose significant threats to human occupancy in SAC localities.

5.2.3.3 Environmental, social and health management plan

The Environmental, Social and Health Management Plan (ESHMP), proposed by STAR Consult for implementation by SAC, based on the 2011 ESHIA, is summarized in Table 50.

Table 50 Environmental, Social and Health Management Plan (ESHMP) proposed for SAC.

Anticipated impacts	**Mitigation measures**
Biophysical environment	
Air pollution	An effective dust suppression programme on haulage routes within or proximal to human settlements; air pollution from the combustion of engines from vehicles, oil processing machinery and generators can be significantly minimized by regular maintenance of engines
Soil degradation	Avoid the establishment of nurseries and plantations on sloping terrains; carrying out land clearing during the dry season and only land that will be cultivated; heavy farming equipment should not be used during periods of rain to minimize soil compaction; apply only optimal fertilizer doses and promote the use of green manure
Surface water pollution	Conduct land clearing during the dry season to minimize runoff; avoid land clearing on steep slopes closer to water; nurseries and plantations should not be located uphill of drinking water sources; integrated pest management techniques is highly recommended to avoid the use of environmentally unfriendly chemicals like DDT
Socio-economic environment	
Disruption of human settlements and indigenous livelihoods in SAC localities	The project should avoid as best as possible the disruption of human settlements and livelihoods; affected communities should be relocated according to World Bank guidelines as the minimum standard; economy diversification and alternative livelihoods
Increase in migration and associated social problems	Support for the provision of more social facilities to meet the needs of an ever-expanding migrant population; prioritizing employment of indigenes; collaboration for the enforcement of public law and order
Land degradation and community health problems	Adoption of more environmentally friendly agricultural practices; support for an adequate and responsive healthcare delivery system

5.2.4 Natural Habitats Sierra Leone

Natural Habitats Sierra Leone (NHSL) is a subsidiary of the Natural Habitats Group (NHG) and acquired the West Africa Agriculture Number 2 (WAA2) company in Sierra Leone in 2014 to mainstream the use of organic practices in the production of organic and sustainable palm oil. WAA2 owned a lease concession covering 30,700 ha for 99 years in the Makpele Chiefdom of Pujehun District in southern Sierra Leone. In its first five years of operations, the company plans to develop 7,500 ha of oil palm plantations, while supporting independent smallholder farmers in the development of oil palm plantations covering an area of 2,500 ha.

In view of NHSL's commitment to the Roundtable on Sustainable Palm Oil (RSPO) initiative and the national environmental policies of Sierra Leone, a comprehensive and participatory independent ESIA of the concessionary area of NHSL was conducted between 2015 and 2016 to form the basis of an ESMP that will be rolled-out during the project lifecycle. To this end, Integrated Geo-information and Environmental Management Services (INTEGEMS) was contracted to conduct the ESIA of the project based on an assumption of 15,000 ha of company owned oil palm plantations, 5,000 ha of oil palm plantations by smallholder farmers (out-growers) and processing facilities including a palm oil mill and associated infrastructure.

5.2.4.1 Impacts on the biophysical environment

Based on the field data analysis by INTEGEMS, a number of environmental impacts will be attendant with the activities of NHSL. Table 51 presents a summary of anticipated impacts.

Table 51 Anticipated biophysical impacts of NHSL operations in concessionary areas.

Activity	Anticipated impacts
Nursery and plantation development and operation	Loss of species habitats; air pollution from the open burning of biomass; decline in air quality; water pollution from agro-chemicals and sewage; water scarcity; pest infestation; increase in traffic with the transportation of inputs, equipment and staff; changes in local hydrology and deterioration in water quality; decline in air quality; noise nuisance; solid waste management and sanitation issues; loss of biodiversity; threats to resident crops; soil instability and erosion; acidification and deterioration of soil fertility; aesthetics and visual intrusion; occupational health and safety issues; degradation or loss of cultural heritage sites within and proximal to estates
Mill and construction and operation	Air pollution due to emissions from the combustion of palm oil fibre and nutshell obtained from the process and used to fuel furnaces that power the palm oil mill; exhaust emissions from the combustion of stand-by fossil fuel generators; exhaust emissions from the transportation of produce from the plantation to the mill for processing; exhaust emissions from the transportation of crude palm oil for export or to the market by third party trucks; methane emissions from the shallow ponds as a result of the digestion of Palm Oil Mill Effluent (POME) by aerobic and

	anaerobic bacteria; possible use of Ozone Depleting Substances (ODS); chemical pollution of soil resources and water bodies; noise nuisance from machinery

5.2.4.2 Impacts on the socio-economic environment

Agriculture is the mainstay of most inhabitants of Makpele Chiefdom. The operations of NHSL are expected to decrease land availability for farming populations. A number of jobs from indigenous farming will be lost. However, several alternative jobs across the production value chain will be provided by NHSL. Additionally, indigenes employed by NHSL will gain relevant agricultural and other technical skills that will be acquired through job experience and training programmes provided by the company, thus building on the local human capital.

Smallholder agriculture and agribusiness will be enhanced under NHSL operations. Indigenes will implement the out-growers scheme which is expected to empower smallholder farmers in the development of oil palm plantations that will ultimately feed the pam oil mills. This would increase farmers' incomes and hence their ability to meet personal and family needs.

It is important to note, however, that the migrant population in the NHSL operational areas is expected to increase with the influx of job seekers and business people exploiting a growing market. The increase in population is expected to bring several social problems ranging from the spread of diseases to the prevalence of crime, prostitution, alcoholism, and drug abuse.

There is the very likelihood of high community expectations on the development impacts of NHSL operations in host communities. People may be desperate to realize immediate social and economic benefits. If these expectations are not met, there is the tendency for increased tensions between NHSL and the host community which could graduate into violent conflicts.

5.2.4.3 Environmental and social management plan

The Environmental and Social Management Plan (ESMP) proposed by INTEGEMS for implementation by NHSL, based on the ESIA conducted in 2016, is summarized in Table 52.

Table 52 Environmental and Social Management Plan (ESMP) proposed for NHSL.

Anticipated impacts	Mitigation measures
Biophysical environment	
Loss of species habitat	Habitat survey and identification of suitable protected areas; creation of ecological corridors and buffer zones to attenuate species loss within oil palm plantations; development and implementation of an effective biodiversity management plan that includes the delineation of habitats to be left out of oil palm plantations like riparian forests, wetlands, habitats of vulnerable or endangered species; sensitization of out-

	growers on conservation biodiversity issues; creation of an adequate buffer (4 km) between out-growers and the Gola Forest Park; use of remote sensing and GIS tools for monitoring; implementation of the no poaching policy
Changes in local hydrology and decline in water quality	Creation of a 50 m buffer zone between plantations and rivers and 30 m buffer zones around wetland areas to minimize sedimentation and river bank erosion; construction of waste water management (chemical and biological) systems; proper palm oil mill operation and maintenance and POME management; implement technical solutions to allow the use of water in irrigation to prevent non-compliance with guidelines on water quality; technical hydrological considerations during infrastructural development; use of leguminous cover crops to reduce denudation and soil erosion; seasonal monitoring of surface and ground water trends to ensure continuous conformity to regulations on water quantity/quality
Pollution and deterioration of air quality	Procurement of lower emission machinery; covering of transported demolition waste; proper operation and maintenance of the boiler plant and dust control systems; implementation of no burning policy at plantations; dust control along haul roads including the enforcement of reduced speeds around communities and spraying of water on haul roads
Solid waste management issues	Implementation of the solid waste management plan and supervision of landfills; construction of proper sanitary landfills for domestic and industrial waste; recycling of palm oil mill waste either as fuel or as soil amendment; establishment of municipal water management systems; none use of PCBs and asbestos as construction materials; hazardous waste to be transported outside of plantations and palm oil mill area; waste transportation in line with national laws; development of a waste recycling plan; use of demolition waste in other construction works
Soil acidification and decline in soil fertility	Land preparation to be carried out during the dry season to minimize soil compaction or erosion; implement a soil erosion and sediment control plan to intercept, divert or reduce the storm water runoff; planting lines to run perpendicular to slope direction; integration of vegetation and non-vegetation soil stabilization measures (cover cropping, mulching) in the erosion control plan; optimal or minimal fertilizer use to minimize nutrient leaching and contamination of open water resources; organic soil fertilization using empty fruit bunches and leguminous cover crops
Occupational health and safety issues	Implementation of sanitation projects; construction of company clinic so as not to overburden existing community health facilities; proper health and sanitation management across the project value chain; preparation of health and sanitation policies, rules and procedures; enforcement of the use of personal protective equipment (PPE) during work; no smoking in areas of chemicals and hydrocarbons; deployment of fire extinguishers in high risk areas; prohibition of pregnant women and lactating mothers from working with agro-chemicals in plantations and mills; distribution of first aid kits; training on safety, protection and administering first aid
Pest management	Integrated pest management, combining both cultural and biological methods, to minimize the use of pesticides; proper storage of chemicals
Noise nuisance	Use of noise control mechanisms like acoustic insulation; ensure palm oil mill is distant from residential areas; use of noise monitoring tools to keep noise within acceptable limits; adequate maintenance of equipment and fitting with silencers or mufflers to keep noise within the 85 dB limit
Socio-economic environment	

Job opportunities and employment of locals	Periodic review of employment opportunities for host communities to cushion the effects of unemployment due to farmland dispossession; review of events that have led to serious environmental or social impacts
Smallholder and out-grower support schemes	Periodic assessment of the progress made in empowerment schemes on smallholder and out-growers of oil palm plantation in project areas
Economic development	Periodic review of community development and community needs
Social welfare, improvement of local skills and enhanced access to markets	NHSL will receive and review periodic assessment of social welfare, improvement of indigenous skills and enhanced access to markets by the local farmers as a way to monitor project multiplier effects on the socio-economic development and associated challenges and opportunities
Loss of, or reduced access to, agricultural land and indigenous livelihoods	Keeping track of planned and implemented plantation activities and ensuring that adequate farmland is available for local communities; regular consultations with communities through grievance redress systems; engagement of independent institutions in monitoring land tenure, land leases and disbursement of compensations and operations of the grievance redress system; regular review of unusual events that have resulted in social issues as some issues require immediate action/remedy
Population increase and potential conflicts related to peoples' expectations	Effective community engagement on community expectations and periodic assessment of potential conflicts arising from unrealistic expectations and unfair resource allocation or land compensations
Vehicular traffic and road safety concerns	Design and implementation of local road safety programmes (speed limits, speed bumps, GPS monitored company trucks, driver safety training) and monitoring compliance; community awareness on safety
Loss of archaeological site	Preservation of all archaeological sites in line with national policies
Roads and related infrastructure	Roads should be designed to fit geographical and geological settings; erosion control on haul roads through proper drainage construction, intensive road compaction, and planting of road trees/verges to minimize raindrop impact and erosion; roads should be constructed perpendicular to the predominant slope to minimize erosion; regular road maintenance to prevent degradation of road surfaces; ditches to divert storm runoff

5.3 Comparison of LDA and ESHIA Reports

In the preceding sections, several aspects have been reviewed on the ESHIA and ESHMP reports of the four companies operating in the chiefdoms under study. In the current section, a comparison is made between the aforementioned reports and relevant findings of the LDA.

5.3.1 The Biophysical Environment

5.3.1.1 Degradation of Soil Resources

In the LDA study, soils were analyzed for the potential of hydrogen (pH), electrical conductivity (EC), organic carbon (org C), total nitrogen (tN), total phosphorus (tP), exchangeable potassium (Exc K), exchangeable magnesium (Exc Mg), total iron (tFe), arsenic

(As), and cadmium (Cd) to provide indications of soil fertility and soil contamination with pollutants from the mining and agriculture sectors. Soils are generally acidic given the low pH values across land-cover classes. This finding is consistent with the chemical analysis provided in the 2018 ESHIA Report of SRL. While the 2018 ESHIA Report of SRL did not provide any indications of toxic elements that would limit natural plant growth in mining communities, the LDA Report noted the presence of anomalous concentrations of iron in wetland and barren surfaces in Lower and Upper Banta. For Malen and Makpele, the LDA reported iron toxicity in wetland and forest areas. In Lower Banta, anomalous concentrations of arsenic were reported by the LDA in barren surfaces whereas a corresponding observation was made in the wetland class in Upper Banta. The observation that pH values are generally lower in well drained soils, in the 2018 ESHIA Report of SRL, was also consistent with that indicated in the LDA Report. Based on the findings of the LDA Report, soil nutrients required for a healthy plant growth are generally below optimal supply levels across the chiefdoms under study, and a similar observation was reported in the 2018 ESHIA Report of SRL. The decline in soil fertility is among the most anticipated biophysical impacts cited in the ESHIA reports as activities of these companies result in deforestation, soil excavation, soil compaction and soil nutrient leaching due to the increased surface runoff and erosion.

Measures to mitigate these impacts were suggested by these companies and they largely include: minimizing the disturbed footprint of these projects; soil replacement and concurrent rehabilitation; design and implementation of a soil erosion and sediment control plan; and undertaking land preparation during the dry season, to minimize soil compaction or erosion.

5.3.1.2 Deterioration of Water Quality

In the LDA study, water samples were analyzed for pH, EC, total dissolved solids (TDS), total hardness, nitrates, phosphates, sulphates, tFe, As, Cd, and mercury (Hg). Results indicated that pH and EC are higher in mining areas, with TDS, total hardness and sulphates being extremely high. Nitrates and phosphates are lower in mining areas and this is attributed to the less intensive agriculture and hence a lesser application of agro-chemicals that could deposit these substances. However, there are high levels of tFe, As, Cd and Hg in water samples in mining localities. The LDA findings on the presence of heavy metals in water samples above background concentrations are in sharp contrast to the 2018 ESHIA Report of SRL in which no anomalous heavy metal concentrations in the analyzed water samples were reported. Nonetheless, the LDA and SRL's 2018 ESHIA reports showed similar findings on the generally acidic water samples. Additionally, elevated concentrations of aluminium were reported for some wetlands in the 2018 ESHIA Report for SRL, though this element was not analyzed in the LDA study. The deterioration of water quality featured prominently among the anticipated impacts of SMHL, SAC and NHSL though information on their analysis of water samples was not available for this review. In the LDA Report, water quality is better in non-mining communities relative to the active mining communities. This is supported by the observation in the 2018 ESHIA Report of SRL that old mining sites generally recorded a water quality that is comparable to background water quality, and pH and concentrations of aluminium decrease with increasing distance from the Mineral Separation Plant (MSP). It is important to further note that water quality in NHSL areas is also better than those in the SAC operational areas. This can largely be explained by the organic farming approach adopted by the former relative to the later that employs agro-chemicals in soil and crop management. Additionally, SAC has a larger oil palm plantation area and thus its impacts on the environmental system are anticipated to be over and above those recorded in NHSL areas.

In their impact mitigation plans for water pollution, these companies have generally agreed on: sustainable dam removal to allow ecosystem functioning; stockpiles and overburden should be distant from water ways; proper storage of hydrocarbons; implementation of tailings management plan; diversion of rainwater from tailings storage; avoid land clearing on steep slopes closer to water bodies; nurseries and plantations should not be located uphill of water bodies; and integrated pest management methods to avoid using chemicals like DDT.

5.3.2 The Socio-economic Environment

5.3.2.1 Impacts on agricultural land and livelihoods

Based on results obtained from the LDA investigation, about 72% of the households in mining communities and 91% of the households in non-mining communities in Moyamba indicated agriculture as their primary livelihood source. In Pujehun, farming is the mainstay for about 76% of households in mining communities and 83% of households in non-mining communities. This agrees well with the findings in the 2012 ESIA Report of SMHL that about 90% of households in their operational areas depend on agriculture. With the growing concessions of mining and agricultural companies, access to land for farming is becoming increasingly difficult. In Malen for instance, the LDA indicated that 13,800 ha of land is now occupied by oil palm plantations, most of which belong to SAC. This slightly overestimated the SAC reported oil palm plantation area which stood at 12,349 ha in 2019, out of a concessionary area of 18,473 ha. The difference between the LDA oil palm planted area and that reported by SAC can be attributed to private oil palm plantations and associations of the natural wild oil palm ecologies in communities where SAC is not operating. It is important to note, however, that a report published by Green Scenery in 2017 indicated an SAC oil palm planted area of 18,326 ha in the Malen Chiefdom. According to SAC, a substantial portion of their concession has be preserved for the protection of ecosystem services, especially inland valley swamps (IVS) which provide agricultural livelihood sources. This notwithstanding, the 12,349 ha of land that has already been developed by SAC in Malen accounts for about 45% of the total land area of the chiefdom. This indicates a significant loss of farmland by local farming populations in this area and other livelihoods like hunting and logging. In the Makpele Chiefdom, the LDA study mapped an oil palm planted area of 2,800 ha. Similar to Malen, this estimate includes company plantations, smallholder out-growers and associations of natural wild oil palm ecologies. This accounts for just 6.7% of the land area of Makpele.

Strategies proposed by these companies for the mitigation of agricultural livelihood loss include: limit project footprint; integration of GIIP strategies in resettlement actions plans; avoid the disruption of human settlements and livelihoods as much as possible; affected communities should be relocated according to World Bank guidelines on resettlement; economy diversification and generation of alternative livelihoods; ensure adequate farmland is available for the host communities; regular consultations with communities via grievance redress systems; monitoring land tenure, land leases, and disbursement of compensations.

5.3.2.2 Impacts on local employment

Despite the anticipated positive impacts of mining and multinational agricultural companies on employment in their host communities as stated in the various ESHIA reports, the LDA study showed that in Moyamba, only 13.2% of household respondents interviewed in mining communities considered company employment as having a positive impact on livelihoods. This reduced to 11.4% in non-mining communities. The mitigation strategies to employment issues in operational areas of these companies include the periodic review of employment opportunities, for local residents, to cushion the effects of unemployment due to farmland dispossession; prioritizing indigenes during company recruitment; providing support to smallholder farmers as with the empowerment of out-growers in operational areas of NHSL.

5.3.2.3 Impacts on human health

It is observed from the LDA study that 32.7% of households in the areas under investigation have faced health challenges that are attributable to the impacts of company operations. The most commonly reported public health issues in mining communities are waterborne diseases (27.8%), malaria (26.2%) and airborne diseases (23.8%). Within the agricultural areas, malaria (42.5%) is the most frequently reported disease followed by airborne diseases (28.8%) and waterborne diseases (16.4%). In non-mining and non-agricultural company areas, the impacts of company activities on human health are little felt. The mitigation measures proposed by companies in this regard include the provision of more health facilities especially in the wake of the observed population influx into these communities for jobs.

5.3.2.4 Impacts on environmental quality

In mining areas, 81.4% of household respondents perceived negative environmental impacts due to company activities. In agricultural areas, 56.9% of household respondents perceived negative impacts. This observation suggests that mining companies are more perceived to have negative environmental impacts than agricultural companies. In mining localities, the three most commonly perceived negative impacts of companies are loss of farmland (21.1%), water pollution (21.1%), and soil degradation (20.7%). In agricultural areas, the most notable negative impacts of companies are air pollution (26.8%), forest and soil depletion (22.5%), and water pollution (21.0%). These statistics were substantiated by findings obtained from key informants where soil (27.0%) and forest (25.5%) degradation and water pollution (25.5%) were the most perceived impacts of mining. In agricultural areas, forest loss (43.2% of respondents) and air pollution (32.4% of respondents) are the most perceived impacts.

CHAPTER SIX

6.0. Conclusions and Recommendations

6.1 Conclusions

Land degradation has been assessed over the Lower Banta and Upper Banta chiefdoms of Moyamba District and the Malen and Makpele chiefdoms of Pujehun Disctrict in southern Sierra Leone. Based on results obtained from the synergistic application of socio-economic (indigenous) perceptions and scientific methods, the following conclusions have been drawn.

Significant forest degradation has been reported based on indigenous perceptions in the four chiefdoms. This is supported by empirical evidence obtained from Landsat imagery analysed at 2000 and 2020. Forest loss is mainly attributed to the combined influence of local activities (subsistence farming, lumbering, and charcoal production) and mining (in the case of Lower and Upper Banta) and expansions in oil palm plantations (in the case of Malen and Makpele).

Loss of farmland has been reported in Lower Banta and Upper Banta, and this, the indigenes attributed to the expanding mining concessions of companies like Sierra Rutile and Vimetco. Loss of farmland is more pronounced in Malen where almost half of the arable land has been acquired by the Socfin Agricultural Company which holds large oil palm estate concessions. Thus livelihoods from farming, logging and hunting have been significantly eroded in Malen.

Indigenous perceptions suggest that the land tenure systems are highly monopolized by local authorities and compensations, or surface rents are grossly inadequate to provide sustainable and alternative livelihoods after land dispossession. The attendant surplus labour, poverty and food insecurity have been major triggers of dissatisfaction and conflict in these communities.

Employment opportunities provided by companies for indigenes and the delivery of corporate social responsibilities are grossly inadequate in view of the expectations of host communities. Labour intensive and less paid jobs are more available for indigenes due, in part, to their lack of the required qualification for technical and administrative jobs that attract better salaries.

Indigenous perceptions indicate a decline in land surface quality due to deforestation and pollution, which are largely attributable to company activities. This is adequately supported by chemical analysis of water samples which proved that water bodies in mining localities are more polluted than those in non-mining communities and those in Malen where plantation agriculture is intensive are more polluted than those in Makpele with less oil palm plantation.

Satellite image analysis also confirmed indigenous perceptions that significant forest cover loss has taken place over the years, and this is attributed to both company and local activities.

Indigenous perceptions from host communities of mining and agricultural companies indicate an increase in social vices and exposure to diseases since the arrival of these companies. The rate of theft, prostitution, teenage pregnancy, early marriage, and drug abuse are all perceived to have increased with a growing immigrant population working or seeking employment in these companies. Air and water pollution are also perceived serious negative impacts arising from the operations of these companies. Huge amounts of dust particles are released into the atmosphere as machines excavate the earth or as heavy duty vehicles ply the dusty hull roads.

Chemical and solid wastes from mine sites and processing plants, and fertilizers leached from agricultural soils are major sources of water pollution as demonstrated by the high turbidity and anomalous chemical element concentrations in water samples collected over mining and agricultural communities. In exposed communities, residents have reported eutrophication of water bodies, prevalence of skin and eye infections, and respiratory and water-borne diseases.

Farming has been the primary source of livelihood for most inhabitants of the study areas. With the advent of mining and agricultural companies also came land degradation and land dispossession which makes land either unsuitable for crop cultivation or not even available. As a result, there is a growing shift of livelihoods from farming to petty trading for women, bike riding for youths, charcoal production, and others including employment in companies.

While land degradation and unemployment/underemployment are more frequently reported in the Lower Banta and Upper Banta chiefdoms where industrial ore mining activities are intensive, land dispossession and poor compensations or rents are most frequently articulated in the Malen and Makepele chiefdoms where plantation agricultural activities are intensive.

In view of the above, there is a growing dissatisfaction among host communities of mining and agricultural companies. From lack of access to land information and participation in land legislation to marginalization in land deals, land deprivation, poor employment opportunities for indigenes, poor healthcare and social amenities, and an increase in social problems. The activities of companies in these communities have largely been regarded as unprofitable to the indigenes. There is thus a growing perception that some local authorities do not represent community interests, and this sets the stage for conflict as already recorded in previous times. Policy frameworks and dialogue platforms that address these issues are thus urgently needed.

6.2 Recommendations

From results presented in this study, there is the likelihood for the resurgence of violent conflicts not only between landowners and companies but also between pressure groups and authorities, and even between and within families. To mitigate potential conflict and enhance community resilience to prevailing challenges, the following recommendations are proposed.

6.2.1 General Recommendations

1. Effective stakeholder engagement (land owners, local authorities, women and youths) in land tenure and in land deal negotiations, and sensitization on company operations are of utmost importance as this would ensure informed and representative decisions.
2. Environmental monitoring teams/groups should be localized in the communities. Although there are community affairs departments in the various companies, they should be enhanced to effectively address social unrests and environmental issues.
3. The intervention of the Anti-Corruption Commission (ACC), to curb the high levels of corruption among government officials and community stakeholders in land deal negotiations, delivery of community benefits, and utilization of revenues, is required.
4. Decentralization of the operations of the Environment Protection Agency, Ministry of Lands and Country Planning, Ministry of Environment, Ministry of Labour and Social Security, and other relevant agencies of government to enhance greater monitoring of the activities of these companies and to ensure compliance with national regulations.
5. Conducting a comprehensive study on the diverse livelihood options to inform the implementation of alternative livelihood programmes that would enhance community resilience in the face of land degradation, land dispossession, and unemployment.
6. Enhancing human capacity building of local communities through scholarships for formal education and skills training that would better prepare them for the job market.
7. Review of current land tenure systems and enhancing access to land information and inclusivity, especially for women and youths, in land legislations and negotiations.
8. Enhancing the operations of land advocacy and civil rights organisations across communities for effective dissemination of information on land laws and land rights.
9. Ensuring regular reviews of the environmental and social impacts of these companies and their compliance with protocols set in their environmental management plans.
10. Ensuring that companies fulfil their corporate social responsibilities and effective monitoring of such projects to ensure alignment with priorities and value for money.

11. Extension of community development to communities proximal to operational areas of companies as the neighbourhood effect could also expose such communities to the impacts of land degradation, such as flooding and spillage of pollutants into rivers.
12. Effective education and communication of the impacts of company and indigenous activities on the environment through mass media platforms, town hall meetings, school environmental clubs, and training on appropriate local mitigation measures.
13. Deforestation and reduction in wetland (IVS) area is a common denominator across the study areas. Effective reforestation and catchment/watershed management should therefore be at the core of response strategies to the mitigation of land degradation.
14. ESHIAs that formed the basis for the issuance and renewal of licences are conducted by company-hired consultants. Therefore, EPA should ensure the effective screening of consultants and the use of accredited laboratories for data integrity and validity.
15. In view of the recorded pollution of water bodies in mining and oil palm plantation areas, NWRMA should ensure the commitment of companies to pollution abatement policies; the clean-up of polluted rivers and implementing the polluter-pays principle.
16. Strengthening the activities of community development committees in operational areas of mining and oil palm plantation companies in order to ensure accountability and fulfilment of the cooperate social and environmental responsibility of companies.
17. Establishment and capacity building of grievance redress committees in operational areas of mining and oil palm companies as a local platform for conflict mitigation.
18. Considering the growing expansion of land degradation, EPA and NMA should work with development partners and companies towards mechanisms that reduce project footprints without compromising the profitability and sustainability of these sectors.
19. In view of the growing loss of biological diversity and ecosystem services, EPA and partners should ensure the establishment and protection of biodiversity corridors as well as establishing biodiversity offsets to compensate for the environmental impacts.
20. Despite land degradation being mostly attributed to the activities of largescale mining and oil palm companies in the communities that were investigated, policy actions must also address the impacts of artisanal mining, logging, and charcoal production.
21. To ensure compliance, mine rehabilitation and closure bonds must be instituted.
22. In response to the growing dynamics in the extractive sector, the review of the Mines and Minerals, EPA and NMA Acts should seek greater transparency, accountability, and environmental responsibility of all stakeholders in the primary industrial sector.

6.2.2 Recommendations for Mining Communities

1. Introduction of more environmentally friendly approaches to mining and mine waste management to reduce the negative impacts of mining operations on the environment. Government should encourage, especially, the shift from wet (dredge) to dry mining.
2. Water sample analysis in mining communities reveals the presence of heavy metals in water bodies within or proximal to mined-out lands. Clean ups, especially of the large lakes left by dredge (wet) mining, is essential to prevent spill overs to adjacent lands.
3. Extensive reforestation should be implemented across all previously mined ecologies and waste lands in order to restore ecological heath and attendant ecosystem services. The establishment of biodiversity offset areas can be complementary in this regard.
4. To avoid conflict against companies and migrant employees, it is recommended that the employment quota for indigenes be increased and, where possible, provide in-service training for those who lack the expertise or qualification for skilled positions.
5. A significant portion of arable land is available in mining communities. Companies operating in these areas should therefore work towards the strengthening of farming livelihoods through the provision of seeds, fertilizers, and food for work to the locals.

6.2.3 Recommendations for Agricultural Communities

1. Introduction of more environmentally friendly farming practices that employ the use of organic returns and integrated pest management. The government should particularly encourage the shift to the Roundtable on Sustainable Palm Oil (RSPO) guidelines.
2. The reduction in arable land is the most obvious problem with MACs, especially in Malen. Adequate compensations and provision of alternative livelihoods are therefore recommended for these communities to enhance their resilience to land deprivation.
3. Indigenous perceptions suggest that land deals are poor and most beneficiaries are left out during negotiations. Inclusivity and transparency in land deals should therefore be strengthened to enhance greater satisfaction among stakeholders in land transactions.
4. Soil acidity can be addressed by the application of liming materials and to mitigate eutrophication and heavy metal accumulation, organic farming is recommended. This action would requirement active partnership with research institutions like SLARI.
5. Based on respondent views obtained in this study, salaries in agricultural companies generally pale in comparison to those in mining companies. An improvement in the salaries and contract conditions is therefore recommended for agricultural companies.

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