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UNITE DE RECHERCHE ET DE
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Evaluation of social and environmental impacts of gold mining in the locality of Djouzami, Adamawa region of Cameroon

Thesis presented for the partial evaluation with a view of obtaining the Master's degree in Geography

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DEDICATION



TO
MY HUSBAND AND PARENTS

I dedicate this work to my lovely husband Dr. Ing. Mambou Ngueyep Luc Leroy for his unconditional love, moral and financial support and my parents Fotie Appolinaire and Metou Pauline for their good up bringing which has made me the lady I am today.

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ABSTRACT

This work is aimed at contributing to the environmental and social impact assessment of semi mechanised and artisanal gold mining in the locality of Djouzami. In order to achieve this work several researches and field observations were carried out. Questionnaires were also used to complement field investigations. All these enabled the identification of the potential sources of impacts on the human, physical and biological environment. The water samples (E1, E2 and E3) were characterised microbiologically to evaluate the water quality contamination. Environmental tools for impact assessment (Ishikawa diagram, Leopold's matrix and the grid of Gaetan et Raymond) were used and an ESMP was proposed to mitigate the identified impacts. The results of the microbiological analysis showed the abundant presence of Fecal coliforms (FC), Fecal Streptococci (FS) and *Escherichia coli* (E. coli).

The results of our investigations revealed that the population of Djouzami who relied on agriculture as their primary source of livelihood is now massively involved in gold mining, thus, leading to certain household problems as must families turn to neglect their family duties and the education of their siblings. The citizens of this locality are faced with water borne diseases (typhoid, diarrhea, stomach problems) and malaria due to the presence of stagnant waters around the mining sites which act as breeding grounds for mosquitoes. Also, the effluent from the washing of gold containing chemicals and heavy metal vectors is deposited into the river leading to water and soil pollution. All the above results provide ample evidence of the role of mining in the deterioration of water quality making it a primary source of waterborne diseases and vegetation cover. However, mining activity in this environment has also boosted its economic development.

Key Words: impacts, contamination, environment, gold mining, Djouzami.

RESUME

Ce travail de recherche vise à contribuer à l'évaluation de l'impact environnemental et social de l'exploitation semi mécanisée et artisanale de l'or dans la localité de Djouzami. Afin de réaliser ce travail, plusieurs recherches et observations sur le terrain ont été menées. Des questionnaires ont également été utilisés pour compléter les enquêtes sur le terrain. Tous ces éléments ont permis d'identifier les sources potentielles d'impacts sur l'environnement humain, physique et biologique. Les échantillons d'eau (E1, E2 et E3) ont été caractérisés microbiologiquement pour évaluer la contamination de la qualité de l'eau. Des outils environnementaux d'évaluation des impacts (diagramme d'Ishikawa, matrice de Leopold et la grille de Gaetan et Raymond) ont été utilisés et un PGES a été proposé pour atténuer les impacts identifiés.

Les résultats de l'analyse microbiologique ont montré la présence abondante de coliformes fécaux (FC), de streptocoques fécaux (FS) et d'*Escherichia coli* (E. coli). Des moyens de subsistance sont désormais massivement impliqués dans l'extraction de l'or, ce qui entraîne certains problèmes ménagers, les familles devant négliger leurs devoirs familiaux et l'éducation de leurs frères et sœurs. Les habitants de cette localité sont confrontés à des maladies d'origine hydrique (typhoïde, diarrhée, problèmes d'estomac) et au paludisme en raison de la présence d'eaux stagnantes autour des sites miniers qui servent de terreau pour les moustiques. En outre, les effluents du lavage des produits chimiques contenant de l'or et des résidus de métaux lourds se déposent dans la rivière, ce qui entraîne une pollution de l'eau et du sol. Tous les résultats ci-dessus fournissent de nombreuses preuves du rôle de l'exploitation minière dans la détérioration de la qualité de l'eau, ce qui en fait une source principale de maladies d'origine hydrique et du couvert végétal. Cependant, l'activité minière dans cet environnement a également stimulé son développement économique.

Mots clés : impacts, contamination, environnement, mine d'or, Djouzami.

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GENERAL INTRODUCTION

During the last years, our planet was marked by environmental modifications with more discordant consequences especially with the upcoming of the concept of sustainable development. All these modifications poses a lot of problems where by the most essentials come from the consequences of mining activities especially artisanal [1]. Cameroon is one of the countries in Central Africa that is endowed with many mineral resources such as gold, diamond, iron ore, bauxite ... Gold production in Cameroon dates back to 1934 with a production peak of 717 kg in 1992 [2]. Since then, we observe an accurate increase in the exploitation of gold at small (artisanal mining) and average (semi-mechanised) scales particularly in the Eastern and Adamawa regions due to inflation in the prices of this precious mineral in the world's market and the discovery of several deposits. From that date till now, gold exploitation is still carried out with the use of rudimentary equipments, which certainly causes a lot of damages both at the environmental and socio-economic level. This activity highly perturbates the wellbeing of the population of this zone as they do not consider its consequences on the ecosystem.

Gold being a non-renewable resource, its exploitation is limited with time. Thus, has to be done with a lot of precautions to avoid not only its exhaustion but equally limits its environmental and social impacts.

General context and justification of our choice

Gold mining is a global business with operations on every continent, except Antarctica and gold is extracted from mines of widely varying types and scale. Mines and gold mining operations have become increasingly geographically diverse. China was the largest gold producer in the world in 2016, accounting for around 14% of total annual production. But no one region dominates. Asia as a whole produces 23% of all newly-mined gold. Central and S. America produce around 17% of the total, with N. America supplying around 16%. Around 19% of production comes from Africa.

Shaft mining was previously used to extract gold [3]. During ancient times, large pieces of gold could be extracted with relatively primitive methods and tools, with minimal disturbances to the environment. Today, however, cyanidation methods also known as carbon in leach have

been used extensively in gold extraction and these methods have a detrimental impact on the ecosystem.

The mining and production of gold is indeed an ancient human tradition and presently occurs all over the world [4]. The history of gold mining is commonly associated with both positive and negative social, political, economic and environmental impacts.

In South Africa for example, gold mining resulted in vast volumes of tailings, which have been deposited in impoundments. Poor management of most of the tailings dams resulted in the escape of seepage, adversely affecting soils and water quality.

Gold mining is attracting increasing attention in many countries of the world, the rush towards gold in the mining zones of Cameroon in general and Djouzami in particular is not an exception. This increasingly leads to artisanal and semi-mechanised exploitation of the precious metal. Given the difficult conditions in which it is operated and the negative as well as positive impacts this activity generates, gold mining plays a great role on the local economic activities such as employment through mining operations as well as side services related to this activity. However, the management of artisanal gold mining is not really sharp, therefore supplying little or no information on the diverse risks associated to this activity. This insufficiency in knowledge concerns mostly the negative impacts on human such as health, the mode of life, living environment, cultural behaviours and environmental components.

Thus, this study is been done in order to contribute to the strategic assessment of these impacts on the locality.

It is equally in the view to stimulate sustainable development by proposing measures necessary to improve the living standards of the population of this area as well as their environment that the theme « Evaluation of social and environmental impacts of gold mining in Djouzami » was considered.

Delimitation

Spatial delimitation

The locality of Djouzami equally called Djaorofio is located in the Adamawa region of Cameroon, Mbéré division, and Meiganga subdivision. Situated precisely at 40km away from the Meiganga central town going towards the East. It is precisely located at the east of Djouzami village and bounded by geographical coordinates A ($6^{\circ}14'31.91''\text{N}$, $14^{\circ}24'15.00''\text{E}$), B ($6^{\circ}14'33.53''\text{N}$, $14^{\circ}26'22.43''\text{E}$), C ($6^{\circ}12'36.16''\text{N}$, $14^{\circ}24'15.41''\text{E}$) and D ($6^{\circ}12'36.54''\text{N}$, $14^{\circ}26'22.02''\text{E}$). This locality bounded by Bembaram and Bata belongs to the Mbere ditch. The study area is crossed by the Lom River. The location map of the study area is located in figure 1 below.

Djouzami is situated at 903m of altitude. Its geographic coordinates are $6^{\circ}13'0''\text{N}$ and $14^{\circ}22'60''\text{E}$ in DMS (degree, minutes, seconds). The UTM position is VG38 and the Joint Operation Graphics reference is NB33-06, as seen in figure 1.

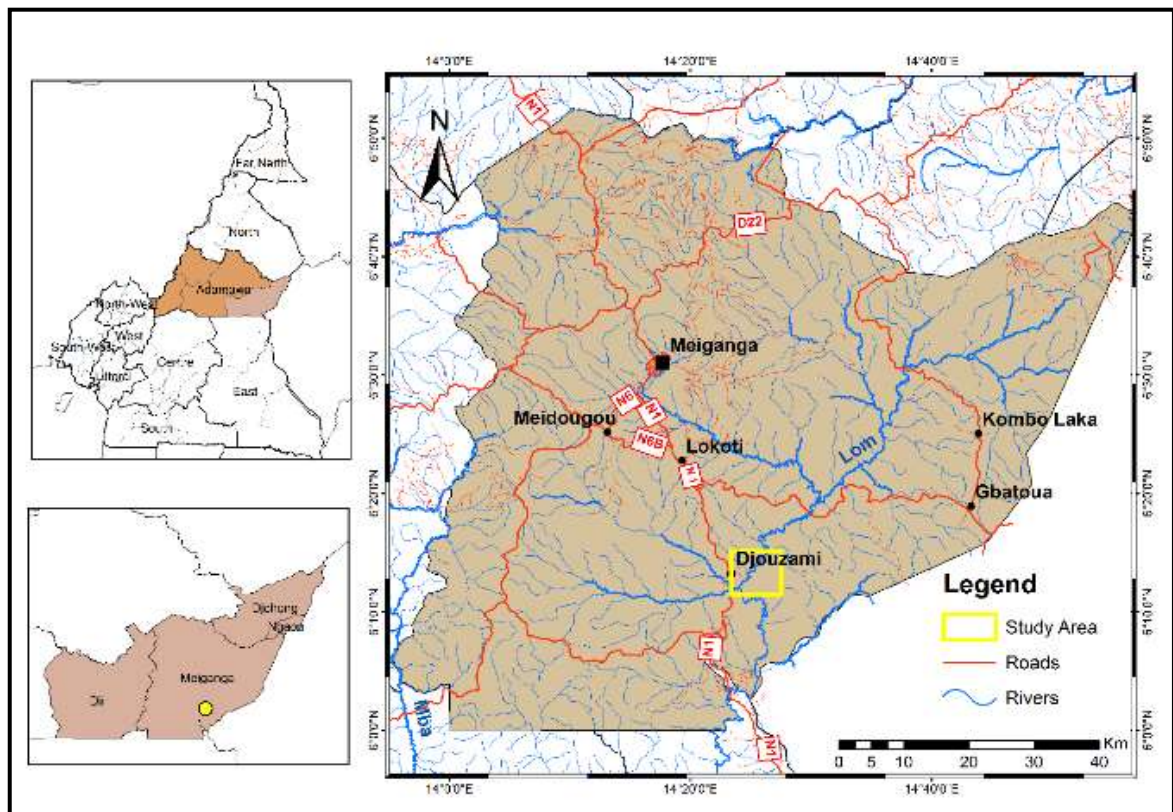


Figure 1: Location map of Djouzami [5]

Thematic delimitation

In the little locality of Djouzami, gold mining is done in two principal manners, which are: semi-mechanised exploitation with excavators and artisanal (gold panning) with rudimentary equipments (spades, basins).

Gold panning here is been practiced by the Gbayas who constitute the local population of this locality and equally by the populations of the surrounding towns (Garoua-Boulai, Meiganga, etc). Semi-mechanised gold exploitation on the other hand is carried out by a South-Korean company settled there since ending 2016 till date. This activity carried out since 2016 in Djouzami generates a lot of impacts on the environment and the socio-economic aspect of the milieu.

Temporal delimitation

Artisanal gold mining has been taking place in Cameroon since 1934. It was more intense in the Eastern region and later on extended to the Adamawa region. The case of Djouzami, subject of our study is of recent (2016). Since then, the environment and lives of the local as well as surrounding population has not been the same due to the damages these activities generates in this milieu. Our study therefore goes from 2016 to 2020 (4 years), after which it was stopped.

Literature review

Environment as used in this study has three components namely, the sum total of external conditions in which organisms exist, the organisms themselves including floral and faunal community and the physical surroundings such as land forms.

According to Pegg in 2003 [1], “ large-scale resource extraction projects can have disastrous local and regional impacts , including toxic contamination of ground and surface water , air pollution , soil degradation , and loss of critical natural ecosystems and biodiversity.”

Artisanal and small-scale mining involves a complex interplay of social, economic, technological, environmental and health factors that can vary considerably across local and national contexts [1].

The Minamata convention on Mercury defines artisanal and small scale mining as ‘‘gold mining conducted by individual miners or small enterprises with limited capital investment and production’’ (United Nations environment programme, 2014). Building on this description, the world bank’s communities, Artisanal and small-scale mining (CASM) initiative elaborates on the economic and social effects of artisanal and small-scale mining work as ‘‘largely a poverty driven activity, typically practiced in the poor and most remote rural areas of a country by a largely itinerant, poorly educated population with little other employment alternatives ‘’ [6].

Gold mining is done using the panning method. Miners use a pan to scoop silt and sand from the river bottom, and sift through it for bits containing gold. This type is mostly done by women. The men use the open pit technique which involves drilling blasting, and removing quantities of soil and sub-soil with their axes and then extract the ore. When the gold is located too far underground for an open-pit mine, they used underground mine. In this case, shafts are dug into the ground, with tunnels of approximately 75m, leading to the gold deposits. These open pits after a while are covered by shrubs and therefore become dangerous traps for visitors, animals, and are breeding grounds for mosquitoes [2].

While Cameroon’s mining sector is still in its embryonic stage, semi-mechanised and artisanal gold mining practiced here has led to significant and unsustainable land degradation, deforestation, health hazards, pollution of rivers and streams [7]. Gold miners are exposed to the risks of physical injuries, respiratory conditions, psychotic disorders, dermatophyte infections, helminthic infestations, malaria and musculoskeletal problems [8]. There are high rates of school dropouts, poor hygienic conditions in the mining camps giving rise to diverse health challenge, high rate of prostitution which leads to the spread of STIs [2]. The process of mining destroys vast surfaces of land by removing vegetation and top soil, and often blasting and drilling into the rock. This means the loss of forest ecosystem. Exhaust fumes, dust, discharge or spills of oils, metals, sediments or other contaminants released into the environment leads to land pollution.

Development of a mine leads to displacement of local people and wild life, marginalisation of price inflation due to the immigration of more people [9].

From the above overview, it can be observed that most studies in this field (to our knowledge) evaluate the different impacts of gold mining in other localities except that of Djouzami. Thus, our work will be among the first in this light.

Problem statement or problem identification

Gold has been a safe investment for centuries. It is insensible to current inflations. Indeed, contrary to the cost of certain mineral resources, that of gold hasn't stopped increasing. This favours an intense extraction of this metal mostly artisanal. In Cameroon, despite the existence of semi-mechanised gold exploitation / extraction, artisanal gold mining occupies an important position.

The contribution of gold panning to the national economy is very significant. The current annual production of gold in Cameroon is estimated at 1.500 kg [10] but no reliable historical gold production data exist. According to the European Union (UE), hardly 10 % of gold produced by the miners is canalised in the formal circuit. Therefore, its contribution to states financial revenue is less than 1.75 billion FCFA per year, that is 0, 26% of global budget.

Gold panning constitutes a source of revenue for the local populations. Indeed, around the exploitation sites revenue generating activities such as small commerce, restaurant, driving spots, etc. Are been developed by the indigenous population and migrants from the surrounding villages. Gold panning therefore is seen as a source of employment and income for the rural populations. Thus, it plays a fundamental role in the socio-economic development of the country and local populations.

The ‘Gold site’ of Djouzami in the Mbéré division, Adamawa region is an example of artisanal gold extraction that generates revenue to the operators.

However, on the exploitation sites we observe the growth of conditions favourable to the appearance of new diseases, the destruction of flora and fauna and the pollution of soils as well as water bodies. This arouses the following questions:

Research Questions

Main questions

- How does artisanal gold mining impacts the environment and population of Djouzami?

Specific questions

- How is gold mining carried out in Djouzami?
- What are the causes of these impacts on the ecosystem?
- How are the impacts caused by gold mining in Djouzami evaluated?
- How can the caused impacts be limited or avoided?

Research objectives

Main objective

The general objective of our study is to evaluate the environmental and social impacts of semi-mechanised and artisanal gold mining in Djouzami and to propose an Environmental and Social Management Plan (ESMP) in order to ensure the wellbeing of the population and safeguard their resources.

Specific objectives

To reach this main objective, the specific objectives include:

- ✓ describing the process of exploiting gold in that locality;
- ✓ identifying the different stages and impacts of gold mining on the different components of the ecosystem;
- ✓ characterising and evaluating these impacts;
- ✓ elaborating an environmental and social management plan with measures of compensation and attenuation of potential risks.

Research Hypothesis

Main hypothesis

The principal hypothesis of our study is that artisanal gold exploitation in the locality of Djouzami creates grievous consequences on the environment and the local populations.

Specific hypotheses:

- gold is exploited in this locality with the use of rudimentary equipment;
- the behaviour of the gold minners on the site are very risky;
- the impacts caused by mining can be assessed through a change in the lifestyle of the citizens of Djouzami;
- an Environmental and Social Management Plan (ESMP) can help limit the impacts of gold exploitation on the environment and population of Djouzami.

Summary of research

Table 1: Synoptic table

Questions	Objectives	Hypothesis	Methods	Chapter
How is gold mining carried out in Djouzami?	Describing the process of gold exploitation in Djouzami	Gold is exploited in this locality with the use of rudimentary equipments	Semi mechanised and Artisanal	Chapter 2
How does artisanal gold mining impacts the environment?	Evaluate the environmental and social impacts of semi mechanised and artisanal gold mining in Djouzami	artisanal gold exploitation in the locality of Djouzami creates grievance consequences on the environment and the local populations.	Matrice of Leopold	Chapter 3
What are the causes of these impacts on the environment?	Identifying the causes of these impacts	The behaviour and the technic of the gold miners on the site very risky	Cause and Effect Diagram	Chapter 3

How are these impacts evaluated?	Characterising and evaluating these impacts,	These impacts can be assessed through a change in the lifestyle of the citizens of Djouzami	Martin Facteau Grid	Chapter 4
how can these impacts be limited?	Elaborating an environmental and social management plan with measures of compensation and attenuation of potential risks	An Environmental and Social Management Plan (ESMP) can help limit the impacts of gold exploitation on the environment and population of Djouzami	Environmental Management Plan	Chapter 4

Methodology

Materials and Field equipment

The materials used to carry out the field work are summarized in Table 2.

Table 2: Field materials and their roles.

Materials	Role	Photos
Global Positioning System (GPS)	Used to collect the geographic coordinates of the sampling points.	
Plastic bottles (1.5 liters)	Used to collect water samples	

A scotch and a bold marker	Used to label the collected samples	
A field book and a pen	Used for taking down observations made on the field	
A phone (iPhone 7 plus, 128gb)	Used in taking Photos	

Source : Mefomdjo, november 2020

Equipment used for microbiological analyses

The materials used in carrying out the microbiological analysis are displayed in Table 3.

Table 3: Materials used for microbiological analysis and their roles

Material	Role	Photo
Petri dish	Used to spread out the solution and the culture environment	
Beaker	Used to conserve the culture environment	

Scale	Used to weigh substances	
Test tube	<u>Used to preserve solutions</u>	
Erlenmeyer	Containing the reactive.	

Source : Mefomdjo, november 2020

In order to provide answers to our main objective, the different methods described below will be used to collect the required data for this study.

Documentary research

This required the consultation of articles, thesis and journals. These documents were consulted in the school library and that of the department of geography, (University of Yaounde I). The library of EGEM (School of Geology and Mining Engineering of the University of Ngaoundere) and over the internet, from this documentary research. It appears that studies on artisanal gold mining has already been done by researchers of different branches. Documents produced are mostly “study report and journal articles. The subject matter is mostly based on the technics of extraction, environmental and socio-economic aspects of gold mining. Its sanitary aspect is equally mentioned.

This research enabled us to define certain concepts and know the socio-economic, sanitary and environmental stakes of gold mining.

Field investigations

Field investigations were essentially based on collecting data. Before collecting field data, we proceeded to the choice of the site and demographic sampling.

The choice of the site

The locality of Djouzami is chosen in the Meiganga sub-division due to the recent discovery of gold (end 2016) and the development of gold mining as the main activity of the residents. As such, no studies have been carried out concerning this activity in that locality yet.

Demographic sample

In order to identify the different impacts linked to this activity, we had to investigate gold diggers, washers, refiners. Due to the high mobility of these diggers, the size of the population on the site remains unknown. But, in order to obtain necessary information, 51 individuals responded to the questionnaires out of 92 who were interviewed, making a total of 143 people. This was treated and used to process the enquiry form.

Data collection

Working tools that helped in the collection of data are questionnaires, interview guide a phone for pictures and direct observations.

Questionnaires are based on the perception of gold diggers on the environmental and social impact of their activity. Their knowledge on chemical products and mode of life will equally be approached.

Interview guides concerns the perception of resource persons on the consequences of chemical products, the manner in which they work and settle, on their health and environment. It will equally consider the positive impact of gold mining in this division and region in general.

Data collection is done in 2 stages, which are,

- Exploration of the site that enabled us know the site and test our questionnaires. It lasted for one week (10-17 November 2020),
- Investigations that was carried out from Nov 20th to Nov 30th (through questionnaires, direct observation, interviews etc).

Data treatment

The treatment of data is done with different softwares. According to the data collected excel 2013 or 2019, SPSS 9,0 or ArcView 3.2 a is used.

However, cartographic data is treated with softwares such as global mapper, surfer, QGIS.

Method of microbiological analysis

The water sample E2 collected from the drinking borehole was collected in a 0.5l plastic container and was immediately kept in an ice cooler and then transported for microbiological analysis in the Biology Laboratory of the University of Yaoundé I.

The bacteria analyzed were: Fecal streptococci (FS), Escherichia coli (E.Coli) and Fecal coliform (FC).

Fecal streptococci

It is an indicator of the global microbiologic quality of water and was analyzed according to the method of agar incorporation described by the norm.

Procedure

A series of decimal dilution of each sample was realized. 1ml of each of the solution was introduced into a Petri dish which was then filled up to 15ml with Plate Count Agar (PCA) culture media. After the solidification of the culture media, the petri dishes were incubated at 35°C for 24 hours. After which the number of bacteria colonies developed in each dish was counted and the bacterial charge of the sample is expressed in colony formation unit/ml (UFC)/ml).

Fecal Coliform (FC)

It is an indicator of the presence of fecal contamination in water and their survival in the environment is similar to that of enteric pathogens. Hence, their presence in water indicates the presence of entero-pathogens. This flora is counted according to the method described in the norm.

Procedure

0.1ml of the solution was placed in the surface of a Mac Conkey agar content in the petri dish by spreading. This was then incubated at 44°C for 24 hours after which the pink coloured colonies formed were numbered and the charge was estimated.

.E. coli

It is an indicator of recent faecal contamination which indicates the presence of pathogens.

Procedure

1ml of each of the solution was introduced into a Petri dish which was then filled up to 15ml with Plate Count Agar (PCA) culture media. After the solidification of the culture media, the petri dishes were incubated at 35°C for 24 hours. After which the number of dark coloured and flat bacteria colonies developed in each dish was counted and the bacterial charge of the sample is expressed in colony formation unit/ml (UFC)/ml).



Photo Mefomdjo, November 2020

Photo 1: Photo of Petri dish containing colonies

Method of identifying the impacts

To **identify the impacts**, the matrix of **Leopold** is used to systematically identify all the possible impacts susceptible to generate from each activity of the artisanal and semi mechanised gold exploitation. It is a table with two entries used to enable us visualise the different relationships between the sources of impacts and the receiving milieu.

The sources of impacts representing the different stages in the artisanal extraction of gold while the receiving milieus are the components of the environment undergoing disturbances.

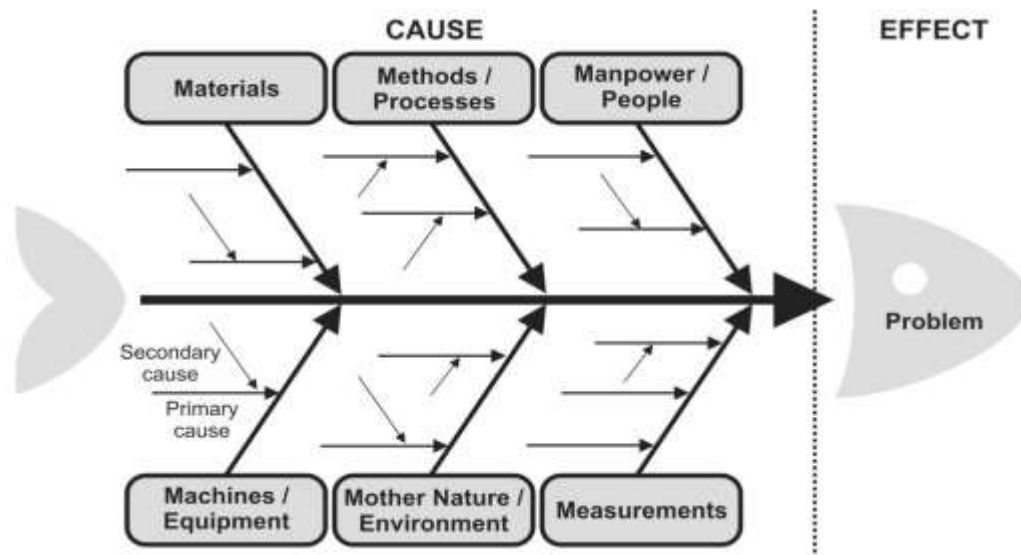
Impact Description

This consist of presenting the causes, manifestations and the effects of each impact identified. The Ishikawa diagram was used in our work to relate the cause of each problem to its effect. The diagram is a fishbone diagram with the effect displayed at the head or mouth of the fish and the different causes listed in small bones under various cause categories; (material, machine, milieu, man power, method and measurement).

There are four steps to using this tool:

- identify the problem;
- work out the major factors involved;
- identify the possible causes;
- analyse your diagram.

ISHIKAWA DIAGRAM



Source : [5].

Figure 2: ISHIKAWA DIAGRAM

Method of characterizing and evaluating the impacts

Following the need to classify or characterise the impacts in one of the categories such as: major impacts, average impacts and minor impacts; the rating grid of Gaetan et Raymond (2000) [11] will serve as a basic methodology guide to evaluate the impacts identified. Thus, we shall say that ratings varying from 1 to 3 will be assigned to the significance of the impact.

In this study, the main classification parameters (characterisation) used are;

- **Nature:** this is the intrinsic character of an impact which precise if the impact is positive or negative.
- **Occurrence:** the occurrence or frequency of an impact refers to the number of times it happens and is evaluated on a scale of 1 to 3 whose meanings are as follows;
Rating 1: impacts are unlikely to occur or less probable.
Rating 2: probable impacts, i.e likely to occur.
Rating 3: impacts are certain to occur.

- **The Scope:** it designates the spatial influence of an impact. The extend or scope of the impact is related to the spatial dimension such as length or area affected. It can have a punctual, local or regional dimension and is rated from 1 to 3 well.
Rating 1: designates an impact of a punctual dimension that is limited to the direct area of the project.
Rating 2: designates an impact of a local influence i.e. can affect the entire locality.
Rating 3: designates an impact with a regional scope, that is one which extends more than 10km from the project site and likely to affect an entire region.
- **Magnitude:** it is the degree of disturbance of the environment which depends on the degree of sensitivity or vulnerability of the component studied. This parameter is broken down as follows:
Rating 1: **low intensity impact**; the activity positively or negatively affects a component of the environment, but in such a barely perceptible manner that the damage observed does not affect the receiving environment.
Rating 2: **impact of medium or average intensity**; the activity affects the environmental component in a moderate way without compromising it.
Rating 3: **impact of high intensity**; the activity that is a source of the impact significantly alters or improves one or more components of the environment, calling into question or increasing their integrity, reducing or increasing significantly its use, characteristics or quality.
- **Duration:** it indicates the manifestation of the impact over time. We then distinguish the following variations;
Rating 1: **short term impact**; the disturbance ends with the end of the impact activity.
Rating 2: **average term impact**; the disruption time lasts some time after the end of the activity that is the source of the impact.
Rating 3: **long term impact**; impacts that persist for a long time after activities cease.
- **Reversibility:** it describes the probability that an element of the affected environment will recover to its initial state over time. It can be natural or induced by mitigation or optimization measures proposed. In the latter case, it also measures the effectiveness of the measures proposed. This parameter is equally rated from 1 to 3.
Rating 1: it designates a rapidly reversible impact.

Rating 2: designates an impact that is reversible over time or requires human intervention for its acceleration.

Rating 3: designates an irreversible impact.

- **Absolute Importance:** the absolute importance of an impact is obtained from the ratio of the average of ratings of the impacts by the total number rated indicators. It is given by:

Absolute importance = sum of ratings (magnitude + scope + duration + reversibility + occurrence)

Thus, the degree of significance of the impacts will be defined according to the results obtained in the following distribution:

- Rating between (1-1,6) represents non significant impacts;
- Rating between (1,7- 2,2) represents significant impacts;
- Rating between (2, 4- 3) represents very significant impacts.

Table 4: Criteria for impact evaluation

Criteria	Symbole	Importance
Nature	+	Positive
	-	Negative
Importance	1	Minor
	2	Average
	3	Major
Probability	1	Rare
	2	Probable
	3	Inevitable

Source: [11]

The criticality is given by the formula below:

$$C = N \times I \times P$$

Where: **C** = **criticality**, **N** = **nature**, **I** = **importance** and **P** = **probability**

The determination of the level of criticality will make it possible to prioritize the impacts during the elaboration of an environmental management plan (EMP) and the mitigation or remediation measures. Priority impacts for the implementation of measures of attenuation are those having a negative nature and rating of high criticality.

Risk assessment is done using the Failure Modes, Effects and Criticality Analysis known as FMECA method. This method consists in determining the significance of every failure mode according to its influence on the system behaviour, enabling to assess the impact of the failure on the reliability of the system safety [12]. The probability of a dangerous phenomenon and the severity of its incidental effect help to establish the hierarchy of the possible risks.

Table 5: Risk assessment

Level of probability	
1	Rare
2	Probable
3	Certain
Level of gravity	
1	Negligible
2	Serious
3	Major

Source: [12]

Environmental Management and Social Plan (EMSP)

The proposed environment and social management plan is to assure that the social and environmental impacts and risk identified in the Djouzami locality as a result of gold exploitation are effectively managed at all the different phases of the exploitation. The EMSP is a document which;

- Describes the measures and mechanism proposed to ensure that all the legal and environmental requirements are met.
- Contains observation of the evolution of certain components of the biophysical and human milieu.
- Qualifies the impacts and evaluates the efficiency of the propose measures.

Interest of the study/ Motivation

Cameroon like most countries in the world is doing their best to resolve environmental problems and promote sustainable development. Development always comes along side with impacts on the environment which is a major challenge to humanity [13].

It is true that the primary interest of any artisanal mining activity is to bring about socioeconomic development. However, it is also associated to calamities like deforestation, soil and water pollution and conflicts which affect the daily life style of man.

This is why these activities requires proper follow up and studies to ensure that they are carried out in sustainable manner.

This work does not only aims at obtaining a degree but equally to help assure a safe environment for the surrounding populations and safeguard potential resources of this locality as well as contributing to its sustainable development. Sustainable development will enable the populations to fully carry out economic activities, both at local and national scale.

Plan

This work of ours is organised in four chapters as follows:

Chapter I entitled Presentation of the Milieu in Relation to Gold Mining in Djouzami will describe the locality and changes that took place with this activity.

Chapter II entitled Legal Context and Method of Exploitation will brief us on how gold mining is being done in that locality and the different bodies in charge.

Chapter III named Results will essentially represent the results from questionnaires, analysis and evaluation of the various impacts identified.

Discussions of the results obtained and proposals on environmental management as well as measures of remediation and sustainable development is done in **Chapter IV**.

Finally a general conclusion that will recall the problematic, results of analysis as well as the different contributions to this evaluation.

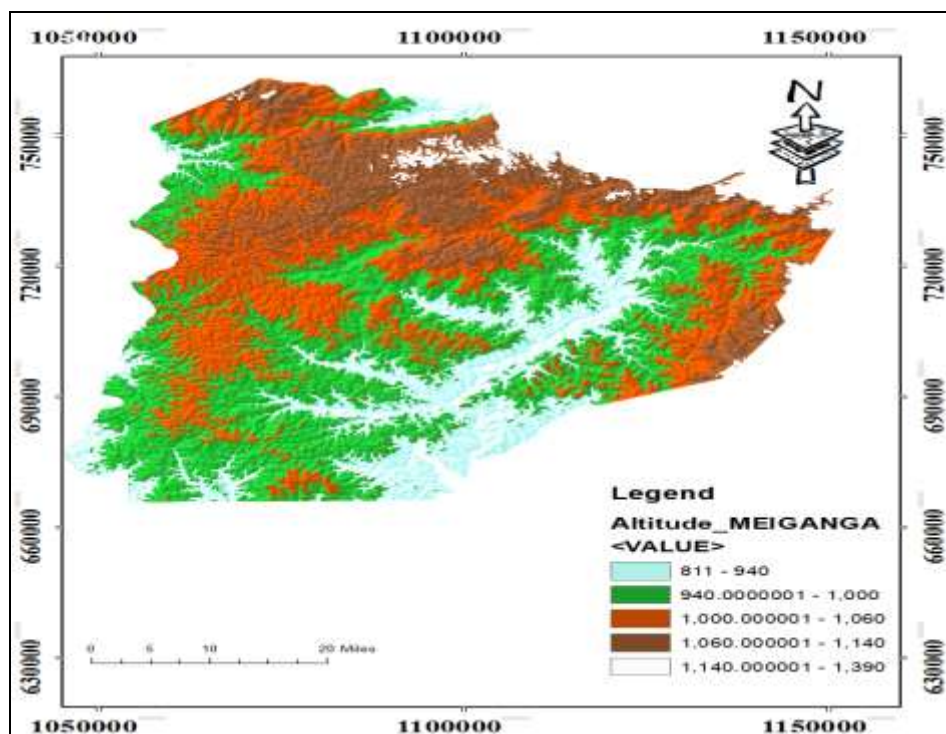
CHAPTER I : PRESENTATION OF THE MILIEU IN RELATION TO GOLD MINING IN DJOUZAMI

Introduction

This chapter describes the study zone (geographic location, its natural and physical environment, its human components), the geologic context of the zone, defines the mode of artisanal and semi mechanized gold exploitation and presents the types of water pollution and mining waste problems.

I.2.1.1. A flat relief suitable for artisanal gold mining

Djouzami is characterised by a non uniform (slightly hilly) relief with hills between 870 m to 990 m and a valley through which flows the Lom river. This locality is situated at an average altitude of 900 m as illustrated in the figure 3.



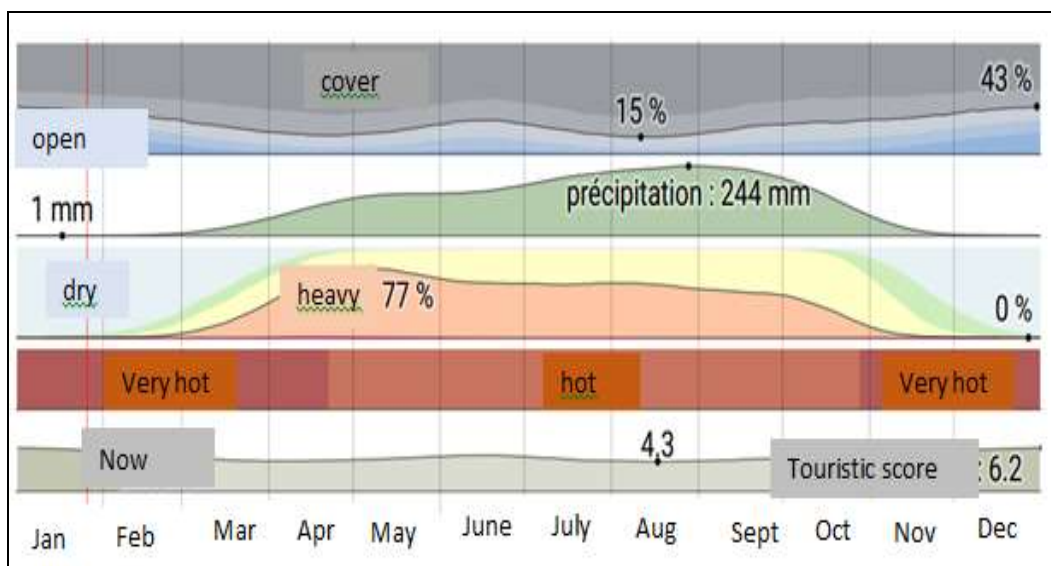
Source: Mefomdjo, Feb 2021

Figure 3 : Topographic map

The low lying nature of this locality plays a major role in facilitating artisanal gold exploitation as the minners will not dig deeper into the ground to find the precious metal. Thus, favouring or encouraging youths, women and children to get involve in this activity thereby abandoning their studies and marital duties in search of gold which eventually exposes the vulnerable ones (children) to diseases.

I.2.2.1 A climate that favors gold exploitation

The climate of this locality is the tropical type with two seasons (the dry season which is very short (4 to 5 months) going From November to February at times March and a very long rainy season (7 to 8 months) from April to October (source: investigations). The average rainfall is about 1600 mm to 1700 mm for a period of 7 months with very heavy rainfall in August and September Djouzami has an average temperature of 23.3° the whole year. The hottest month of the year is that of March with an average temperature of 24.9°c. During the month of July the average temperature is 22.1°c. Thus, it is the coldest month. The difference in precipitations between the coldest and the hottest month is 249mm a variation of 2.8°c is registered within the year [14] (see figure 4).



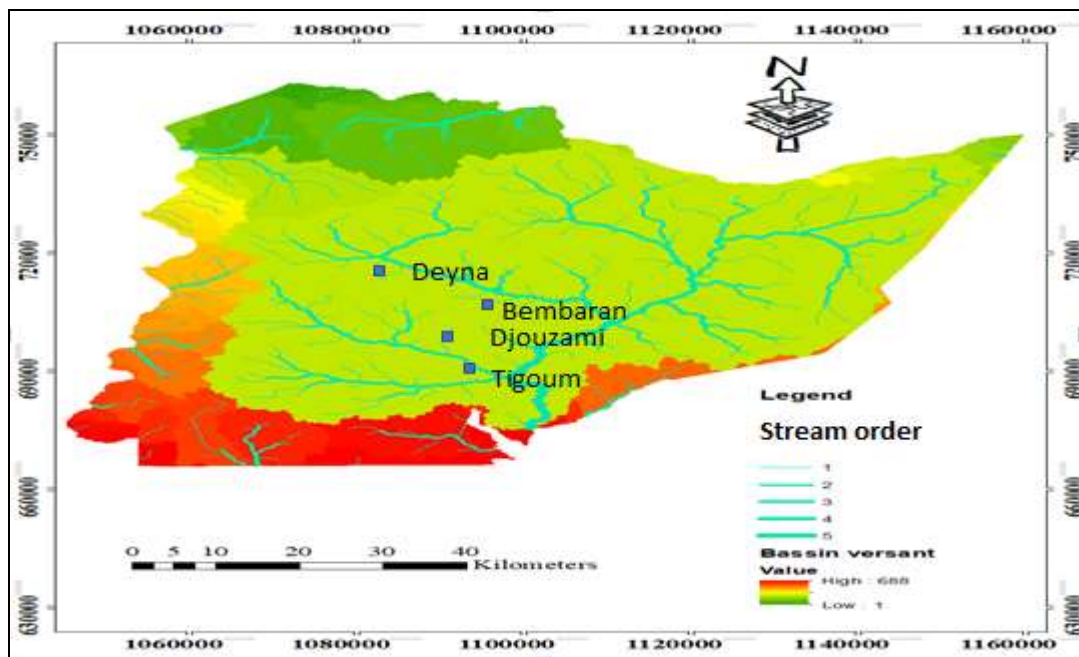
Source : [15]

Figure 4 : Climatic diagram

Artisanal gold mining in Djouzami is carried out with the use of rudimentary equipments with no safety measures taken by the miners. As such, they are exposed to very harsh climatic conditions which is a danger to thier health on this mining site.

I.2.2.2. Hydrology and gold exploitation in Djouzami

The hydrology network of the locality of Djouzami is made up of water bodies such as Torfere and Fell on the western side of the village and Mir on the eastern part. The little Lom and Mba flows across the road.



Source: Mefomdjo, Feb 2021

Figure 5: Hydrology map

The hydrographic network of Djouzami is the main factor behind gold exploitation there as it favors the deposit of this mineral. As such, miners have to deviate the water body from their main course in order to carry out their activity as is the case in Djouzami thereby creating environmental instability. The said activity contaminates these waters used by the populations for daily activities including drinking and then destroying their health.

I.2.2.3. Soils, source of gold and its exploitation

There are principally two types of soils found in this locality, the tropical ferogenous (in majority) and feralitic (in minority) [5]. Feralitic soils are present in areas with thick layers of laterite mostly clay loam at time showing surface layer of quartzites [5]. These soils are generally fertile and suitable for agriculture and animal husbandry. The basement soil is also rich in extractable mineral resources such as gold, diamond, stones, whose exact potential is yet to be known.

Since the exploitation of gold in Djouzami began, its population tends to concentrate on gold exploitation at the expense of agriculture and animal husbandry which was their former principal source of livelihood, though having very fertile soils for that. As such, the environment is being destroyed in search of gold.

I.2.3. The natural environment

I.2.3.1. A vegetation that facilitates gold mining

The vegetation, just like that of Meiganga and Ngaoundere disappears during the dry season and disintegrates. It is made up of a dense shrub Savanna. The Herbaceous layer during the rainy season is very dense up to a height of 1.5m [5] as shown in the photo 2 below.



Photo Mefomdjo, november 2020

Photo 2: Vegetation

The vegetation of Djouzami has undergone massive destruction since the beginning of gold exploitation, leaving behind artificial lakes which act as breeding grounds for mosquitoes that increase the rate of malaria and equally pills of soils.

I.2.3.2 Gold mining and the disappearance of existing fauna

The fauna of the locality of Djouzami is very rich in various animal species. Thus, we find among others the pangolin, gazelles, warthogs, hedgehogs, tortoise, wild boars, wood snakes, does, vipers, epic pigs, palm rats, partridges and other species of small jibiers. In the aquatic environment, the different species of fish are; tilapia caroes and sillures. However, this fauna, which in the past was very rich, is today in marked regression or disappearance due to the intensity of gold mining.

I.2.4. The human environment

I.2.4.1. Social and traditional structuring of the locality

The Djouzami village is made up of 6 districts namely: Gbagamssara, Bogbayock, Toum, Gboda, Gbezai and Gbogotio. The administrative structure present in this village is the 3rd degree chieftdom with a traditional chief still called djaoro and a sub-chief at its head.

In addition, in Djouzami we note the presence of public places such as: a public primary school headed by a director assisted by his collaborators (two mistresses) and a hangar for the market. But also places of prayer whose religious leaders are: the head of the Muslim community and the pastors of Protestant, EEC and Adventist churches.

I.2.4.2. Population

The population of the locality of Djouzami is made up of the Gbaya, Fulbe and Bororo peoples mainly but also of the bordering populations Bamileke, Betis, Massa, Hausa, etc. This is a rather young population according to the one surveyed with an age range that varies from 0 to 80 years.

Religion and the traditional structure;

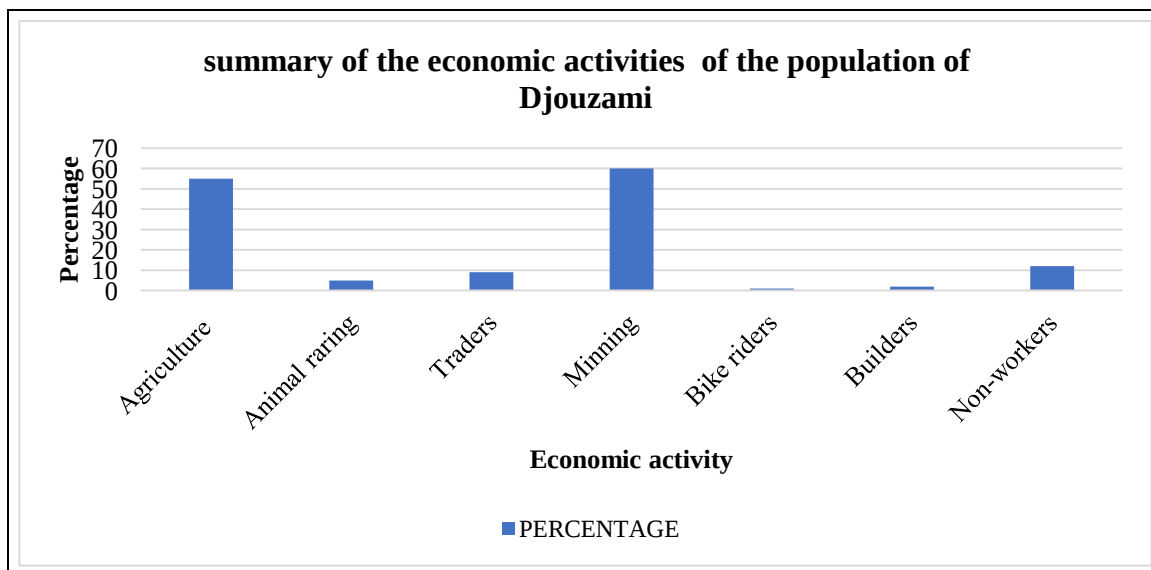
A large part of the population are protestants but there are also a few from different Christian dominations in this area including; Muslims, and Catholics. Their main religious persuasions are presented in the Table 6:

Table 6: Statistics table

Ages	Frequences	Percentage	Religion	Frequences	Percentage
<=30	57	55.9	Catholique	4	3.9
] 30-40]	16	15.7	Protestant	46	45.1
] 40-50]	14	134.7	Muslem	36	35.3
] 50-60]	5	4.9	None	10	9.8
>60years	4	3.9	TOTAL	96	945.1
TOTAL	96	94.1			

1.2.4.3. Economic activities in the study area

The population of the locality of Djouzami carried out several activities for their subsistence; Thus, there are essential activities for this purpose, namely: agriculture for local consumption (maize, yams, cassava, sweet potatoes, peanuts and vegetables, etc.); the breeding of cattle, livestock and poultry (oxen, sheep, goats, chickens and ducks) . In addition to the activities mentioned there was trade though not important and was based on manufactured products and some agriculture. Masonry and motorcycle taxi were not to be outdone. In the small town of Djouzami, let us specify here that there were also people without any activities carried out. Thus, as part of our study, the percentage values attributed to this census on these activities are listed in figure 6:



Source: Investigations, November 2020

Figure 6: *Summary of the economic activities of the population of Djouzami*

With the outbreak of gold mining in this area, these activities have witnessed a rapid decrease thereby reducing their standard of living and creating a very unsecured environment for its populations.

CONCLUSION

Semi mechanised and artisanal gold mining is a very important activity in the locality of Djouzami which started in 2016 and ended in 2020 due to the exhaustion of this mineral. It has proven to be responsible for very serious environmental and social consequences in that area as it attacks the natural environment by the destruction of vegetal cover and the ecosystem. It equally changes the quality of life of the population directly concerned and the neighboring ones due to its impacts on their health and social security.

CHAPTER II : LEGAL CONTEXT AND METHODE OF EXPLOITATION

This part of our work will aim at defining and description of the actual development of these two forms of exploitation and equally stating the roles of the actors as well as the laws that governs mining.

II.1. LEGAL CONTEXT

This legal framework is largely borrowed from [16] who made a presentation worthy of interest within the framework of the Environmental and Social Impact Study of the Lom Pangar dam in 2005 in its Mines section.

The legal, regulatory and institutional aspect of the Mines theme is essentially based on:

- Law N° 2002/004 of April 19, 2002 on the investment charter in the Republic of Cameroon,
- Law N°. 001 of April 16, 2001 on the mining code and its implementing decree No. 2002-648 PM of March 26, 2002,
- Law N°. 96/12 of August 5, 1996 on the framework law on environmental management and whose provisions are incorporated into the mining code and its aforementioned implementing decree,
- Order No. 064 / PM of 7/25/2003 on the creation, organization and operation of the Support and Promotion Framework for Mining Crafts (SONAMINE).

Cameroon therefore has a legal arsenal that regulates mining activity so that the modalities of the exercise of exploration, exploitation and even the sale of the products of the mine, whether artisanal or industrial.

Management law no. 96/12 of 05 august 1996 relating to environmental management

Part i general provisions

Article 1: This law lays down the general legal framework for environmental management in Cameroon.

Article 2:

(1) The environment constitutes a national common heritage in the Republic of Cameroon. It is an integral part of the universal heritage.

(2) Its protection and the rational management of the resources it provides to human life are of general interest. These resources concern mostly the geosphere, the hydrosphere, the atmosphere, their material and immaterial content, as well as the social and cultural aspects they comprise.

Article 3:

The President of the Republic shall define the national environmental policy. Its implementation shall devolve upon the Government, which shall apply it, in collaboration with the decentralized territorial authorities, grassroots communities and environmental protection associations. To this end, the Government shall formulate national strategies, plans or programmes for the conservation and sustainable use of environmental resources.

Chapter I

Definitions

Article 4 :

For the purpose of this law, and its enabling instruments, the following definitions shall apply:

«air »:

Shall be the elements comprising the atmospheric fluid and whose physical, chemical or any other modification may threaten living things in ecosystems and the environment in general;

«Environmental auditing»:

Shall be the systematic, documented and objective appraisal of the situation ,of the management of the environment and its resources;

«Waste» :

Shall be any residue from a production, processing or utilization process, any substance or material produced or, more generally, any movable and immovable goods abandoned or intended to be abandoned;

«Sustainable development»:

Shall be a mode of development which aims at meeting the development needs of present generations without jeopardizing the capacities of future generations to meet theirs;

«Ecology» :

Shall be the study of relationships existing between the various living things and their surroundings;

«The ecosystem» :

Shall be the dynamic complex comprising the community of plants, animals, micro-organisms and their living environment which, through their interaction, make up a functional unit;

«Effluent» :

shall be any processed or unprocessed liquid and gaseous evacuation of domestic, agricultural or industrial origin, discharged directly or indirectly into the environment;

«Waste disposal»:

Shall be all the operations comprising the collection, transportation, storage, and processing necessary for the recuperation of useful materials or energy, and for their recycling, or any deposit or discharge of any other product in appropriate areas under conditions geared towards avoiding harmful substances and environmental degradation;

«The environment» :

Shall be all the natural or artificial elements and bio geochemical balances they participate in, as well as the economic, social and cultural factors which are conducive to the existence, transformation and development of the environment, living organisms and human activities;

«Ecological balance» :

Shall be the relatively stable relationship created progressively in time between man, the fauna and flora, as well as their interaction with the conditions of the natural environment in which they live;

«Classified establishments»:

Shall be establishments which are sources of danger or disaster threatening for the security, sanitation or the convenience of the neighbourhood or for public health, agriculture and for fishing;

«Human settlements»:

Shall be all the urban and rural centres irrespective of their type and size, and all facilities they must contain to ensure a sound and decent existence for their inhabitants;

«Environmental impact assessment»:

Shall be any practical measures ensuring that waste is managed in such a way as to protect human health and the environment, against the harmful effects this waste may have;

«Waste management» :

Shall be the collection, transportation, recycling and elimination of waste, including the monitoring of disposal sites.

Chapter II

General obligations

Article 5:

The laws and regulations shall guarantee the right of everyone to a sound environment and ensure a harmonious balance within ecosystems and between the urban and rural zones.

Article 6:

(1) Public and private institutions shall, within the context of their competence, sensitize all the populations on environmental problems.

(2) The institutions shall consequently include programmes in their activities to provide better knowledge of the environment.

Article 7:

(1) All persons shall have the right to be informed on the negative effects of harmful activities on man, health, and the environment, as well as on the measures taken to prevent or compensate for these effects.

(2) A decree shall define the context and conditions for exercising this right.

Article 8:

(1) Associations regularly declared or recognized as publicly useful and exercising their statutory activities in the field of environmental protection may only contribute to the actions of public and semi-public environmental institutions following an authorization issued in keeping with the terms and conditions laid down by special instruments.

(2) Authorized grassroots communities and associations contributing to all actions of public and semi public institutions working for environmental protection may exercise the rights of the plaintiff with regard to facts constituting a breach to the provisions of this law and causing direct and indirect harm to the common good they are intended to defend.

Chapter III

Fundamental principles

Article 9:

Within the framework of the laws and regulations in force, rational environmental and natural Resource Management are based on the following principles:

- a) the principle of precaution, according to which lack of certainty, given the current scientific and technical knowledge, should not retard the adoption of effective and commensurate measures aimed at preventing a risk entailing serious and irreversible damages for the environment at an economically acceptable cost;
- b) the principle of preventive action and correction (through priority at the: source) of threats to the environment by using the best available techniques at an economically acceptable cost;
- c) the pollute and pay principle according to which charges resulting from measures aimed at preventing, reducing and fighting against pollution and the rehabilitation of polluted areas shall be borne by the polluter;
- d) the principle of liability according to which any person who, through his actions, creates conditions likely to endanger human health and the environment shall eliminate or cause the said conditions to be eliminated in such a way as to avoid the said effects;
- e) the principle of participation according to which:
 - each citizen shall have access to information on the environment, including information on dangerous substances and activities;
 - each citizen shall have the obligation to safeguard the environment and contribute to its protection;
 - corporate bodies and private citizens shall, in all their activities conform to the same requirements;
 - decisions on the environment shall be taken after consultation with the sectors of activity or groups concerned, or after a public debate when they are of a general nature;
- f) the principle of substitution according to which in the absence of a written general or specific rule of law on environmental protection, the identified customary norm of a given land, accepted as more efficient for environmental protection, shall apply.

Part iii

Environmental management

Chapter i

The national environmental management plan

Article 13:

The Government shall draw up a National Environmental Management Plan. The Plan shall be amended every 5 (five) years.

Article 14:

(1) The Administration in charge of the environment shall ensure the inclusion of environmental concerns in all economic, energy, land and other plans and programmes.

(2) Furthermore, the said Administration shall ensure that the international commitments of Cameroon relating to the environment are introduced in national environmental laws, regulations and policies.

Article 15:

The Administration in charge of the environment shall plan and ensure the rational management of the environment, set up an environmental information system comprising a database on the various aspects of the environment, at national and international levels. To this end, it shall register all scientific and technological data relating to the environment and keep an updated compendium of environmental national laws and regulations and international legal instruments of which Cameroon is a party to.

Article 16:

(1) The Administration in charge of the environment shall draw up a bi-annual report on the state of the environment in Cameroon and table it before the Inter-ministerial Committee on the Environment for approval.

(2) This report is published and widely distributed.

Chapter II

Environmental impact assessment

Article 17:

(1) The promoter or owner of any development, labour, equipment or project which may endanger the environment owing to its dimension, nature or the impact of its activities on the natural environment shall carry out an impact assessment, pursuant to the prescription of the specifications. This assessment shall determine the direct or indirect incidence of the said

project on the ecological balance of the zone where the plant is located or any other region, the physical environment and quality of life of populations and the impact on the environment in general.

However, where the said project is undertaken on behalf of the national defence services, the Minister in charge of defence shall disseminate the impact assessment under conditions compatible with national defence secrets.

(2) The impact assessment shall be included in the file submitted for public investigation where such a procedure is provided for

(3) The impact assessment shall be carried out at the expense of the promoter.

(4) The terms and conditions for applying the provisions of this article shall be laid down by

An enabling decree of this law.

Article 18:

Any impact assessment that does not comply with the prescriptions of the specifications shall be null and void.

Article 19:

(1) The list of the various categories of operations whose implementation is subject to an impact assessment as well as the conditions under which the impact assessment is published shall be laid down by an enabling decree of this law.

(2) The impact assessment shall necessarily comprise the following indications:

- analysis of the initial state of the site and its environment;
- reasons for choosing the site;
- appraisal of the foreseeable consequences of the implementation of the project on the site and its natural and human environment;
- outline of the measures envisaged by the promoter or owner to eliminate, reduce and, if possible, compensate for the harmful consequences of the project on the environment and the estimates of ensuing expenses;
- presentation of other possible solutions and reasons for which the project was selected, from the point of view of environmental protection.

Article 20:

(1) Any impact assessment shall give rise to a reasoned decision by the competent Administration, after approval by the Inter-ministerial committee provided for by this law, Under pain of the absolute nullity of the said decision. The decision by the competent Administration shall be taken within a time- limit of 4 (four) months as from the date of notification of the impact assessment. After this deadline, and in the event of silence from the said Administration, the promoter may begin his activities.

(2) Where the impact assessment is not known or the impact assessment procedure is totally or partially disrespected, the competent Administration, or if need be, the Administration in charge of the environment shall demand the implementation of appropriate emergency procedures to suspend the work envisaged or already initiated. These emergency procedures shall be initiated "without the sanctions provided for by this law.

Chapter III

Protection of the receptor environment

Section I

Protection of soils and the sub-soil

Article 36:

(1) The soil and sub-soil as well as the limited renewable or non-renewable resources contained therein, shall be protected against any forms of degradation and jointly managed rationally by the competent Administrations.

(2) An enabling decree of this law, prepared in collaboration with the administrative units concerned,

shall lay down:

- the specific conditions for the protection and fight against desertification, erosion, loss of arable land and pollution of the soil and its resources by chemicals, pesticides and fertilizers;
- the list of fertilizers, pesticides and other chemical substances whose use shall be authorized or encouraged in agriculture;
- the authorized quantities and the terms and conditions for their use, so that the substances do not endanger the soil quality or other receptor environments.

Article 37:

(1) Holders of mining permits or quarrying permits shall rehabilitate the exploited sites.
2) However, holders of mining permits and quarrying permits may choose to pay the financial cost of rehabilitation carried out by the competent Administration. The amount of and the terms and conditions for paying the relevant charges shall be laid down by an enabling decree of this law.

The corresponding sums shall be paid to the Fund provided for by this law and shall not be earmarked for other uses.

Article 38:

(1) The allotment and management of land for agricultural, industrial, urban or other uses, as well as prospecting, research Or exploitation of sub-soil resources likely to endanger the environment, shall be subject to the prior authorization of each Administration concerned and after the obligatory opinion of the Administration in charge of the environment.
(2) An enabling decree of this law shall lay down the conditions for issuing the authorization provided for (1) the above and the activities and uses which, on account of the dangers they pose for the soil, the sub-soil or their resources, shall be prohibited or subject to special procedures.

Section V

Protection of human settlements

Article 39:

(1) The protection, conservation and enhancement of the cultural and architectural heritage are Of national interest.
(2) They are an integral part of the national policy of environmental protection and development.

Article 40:

(1) Urban development plans and public or private housing development plans shall take into consideration environmental protection while choosing locations for economic activity and residential and leisure zones. Prior to their implementation, these plans must record the obligatory opinion of the Administration in charge of the environment.
(2) Urban centres shall comprise recreational grounds and lawns in a harmonious proportion laid down by urban development instruments and the Law on Forestry given the available space, the land occupation ratio and the population residing therein.

Article 41:

Building permits shall be issued duly taking into account the presence of classified establishments and their impact on the environment, and may not be issued or may be subject to special prescriptions jointly prepared by the Administrations in charge of the environment and housing, where the intended buildings are likely to have negative consequences on the environment.

Chapter IV

Plants classified as dangerous, in-hygienic or Inconvenient and polluting activities

Setion I

Waste

Article 42:

Waste shall be treated in an ecologically rational manner to eliminate or curb their harmful effects on human health, natural resources, the fauna and flora, and on the quality of the Environment in general.

Article 43:

(1) Any person who produces or owns waste, shall eliminate or recycle it, or have it eliminated or recycled in plants authorized by the Administration in charge of classified establishments, after the obligatory opinion of the Administration in charge of the environment. Besides, the person shall inform the public of the effects of waste production, owning, elimination or recycling on the environment and public health, presiding the rules of confidentiality and the measures intended to prevent or compensate its negative effects.

2) The conditions under which waste is collected sorted out, stored, transported, recuperated, recycled or processed in any other way, and finally eliminated to avoid over-producing or wasting retrievable waste and environmental pollution in general shall be laid down by an enabling decree of this law.

Article 44 : The introduction, discharge, storage or transit of waste on the national territory and produced outside Cameroon shall be formally prohibited given the international commitments of Cameroon.

Article 45: A regulation laid down by the joint orders of the competent administrations shall govern the manufacturing, importation, owning with the intention of selling or placing at the

disposal of consumers, making of waste-generating products or materials so as to ease the elimination of the said waste, or if need be, prohibit these activities.

Article 46:

- (1) Decentralized territorial councils shall eliminate household waste, possibly with the competent State services, in keeping with the laws in force.
- (2) Besides, they shall: ensure the elimination of all midnight dumping; ensure the elimination of abandoned dumps with the assistance of the competent State services or authorized enterprises, when the owner or author of the dump is not known or identified.

Article 47:

- (1) The person producing or processing waste shall eliminate the said waste under the joint authorization and monitoring of the Administrations in charge of the environment and mines respectively, in accordance with prescriptions laid down by regulation.
- (2) Waste shall be discharged into dumps that are periodically inspected and which respect the minimum technical norms of dump management.
- (3) Special industrial waste considered dangerous on account of their properties shall not be dumped in stock plants receiving other categories of waste.

Article 48:

- (1) When waste is abandoned, dumped or processed in violation of the prescriptions of this law and its enabling regulations, the authority vested with police powers shall automatically eliminate the said waste at the expense of the said producer, after charging the producer to pay.
- (2) The Administration shall oblige the producer to deposit to a public accountant a sum corresponding to the cost of the work to be done. The competent public accountant shall be appointed by order of the minister in charge of finance.

Article 49:

Waste immersion, incineration or elimination by any procedure in the continental and/or maritime waters under Cameroonian jurisdiction shall be strictly prohibited, duly taking into account the international commitments of Cameroon.

Article 50:

(1) The obligation of general maintenance which the public land dealers are subject to shall include those to eliminate, cause to be eliminated, or recycle waste contained in the land.

(2) The dumping of waste on public land shall be strictly prohibited, including public maritime land such as defined by the laws in force.

Article 51 :

(1) Waste shall only be buried in the sub-soil with the prior joint authorization of the competent administrations which shall lay down the technical prescriptions and special rules to observe.

(2) The burial of waste without the authorization provided for in sub-paragraph (1) of this article shall lead to an excavation, of the waste by the person who) buried it, or, after a charge to pay from the competent Administration, in collaboration with the other Administrations concerned.

Article 52:

(1) Areas damaged by work done without authorization or without observing prescriptions, and sites contaminated by midnight dumps or unauthorized buried waste shall be rehabilitated by officials or the closest possible restoration to their original state.

(2) Where a notice of the competent administration has no follow-up for one year, the State shall rehabilitate the site in collaboration with the other administrative units concerned.

Article 53:

The discharge of a pollutant into the air, water or soil shall be subject to an authorization. The conditions for the issue of this authorization shall be laid down by an enabling decree of this law.

Section II

Classified establishments

Article 54:

Factories, workshops, warehouses, building sites, and on the whole, industrial, cottage industrial or commercial plants exploited or owned by any private individual or corporate body, private or public institution, and which pose or may pose dangers for public health, security, hygiene; agriculture, nature and the environment in general, or disadvantages for the conveniences for the neighbourhood shall be subject to the provisions of the laws and regulations in force on classified establishments.

Article 55:

(1) In order to prevent and control accidents in classified establishments, the official in charge of the classified industrial or commercial establishment shall carry out a study on the dangers involved before opening the said establishment.

(2) The study on the dangers involved provided for in sub-paragraph 1 above shall comprise the following

Indications:

- inventory and description of dangers according to their internal or external origin;
- risks involved for the environment and the neighbourhood;
- justification of techniques and envisaged procedures for risk prevention;
- the plant design;
- exploitation guides;
- means of detection and intervention in the event of a disaster.

Article 56 :

(1) The exploiter of any first or second-class establishment as defined by the law on classified establishments shall establish a specific emergency plan to alert f the competent authorities and neighbouring populations in the event of a disaster or threat of a disaster, the evacuation of persons and means of preventing the disaster.

(2) The emergency plan shall be approved by the competent Administrative which shall regular ensure the good condition and worthiness of the material provided to implement the plan.

Section III

Harmful and/or dangerous chemical substances

Article 57:

(1) Harmful and/or dangerous Chemical substances which, on account of their toxic nature or their

concentration in biological chains, or likely to be a danger for human health, the natural environment, and the environment in general when they are produced, imported into the national territory or dumped into the environment, shall be controlled and monitored by the competent technical administrative units, in cooperation with the Administration unit in charge of the environment.

(2) Radioactive substances shall be governed by a special law.

Article 58: An enabling decree of this law taken jointly by the competent administrative units shall regulate and lay down:

- the obligations of manufacturer and importers of chemical substances intended for marketing, the composition of preparations placed on the market, the volume to be marketed;
- the list of substances whose production, importation, transit and movement on the national territory are prohibited or subject the prior authorization of the Administrative unit in charge of the control and monitoring of chemical, harmful and dangerous substances;
- the conditions, mode, itinerary and schedule of transport, as well as all prescriptions relating to the conditioning and marketing of the substances mentioned above;
- the conditions for issuing the prior authorization;
- the list of substances whose production, importation, transit and movement on the national Territory are authorized.

Article 59 :

(1) The chemical, harmful and dangerous substances manufactured, imported or sold in violation of the provisions of this law shall be seized by the officials in charge of suppressing fraud, or those on oath from the competent. Administrative units.

(2) When the substances mentioned in (1) pose a real and imminent danger, they shall be destroyed or neutralized as soon as possible by the Administrative units mentioned in (1) above, at the expense of the offender.

Section IV

Chapter V

Natural resource management and biodiversity conservation

Article 62:

The protection of nature, the preservation of animal and plant species and their habitat, the maintenance of biological balances and ecosystems and the conservation of biodiversity and genetic diversity against all causes of degradation and threats of extinction are of national interest. It shall devolve on the Administration and each citizen to safeguard the natural heritage.

Article 63:

Natural resources shall be managed rationally to meet the needs of the present generations without comprising the capacity of future generations to meet their own needs.

Article 64:

- (1) Cameroon's biodiversity is used sustainably, especially through:
- an inventory of existing species, particularly of those that are endangered;
 - management plans of species and the preservation of their habitat;
 - a system on the control of access to genetic resources.

(2) Biodiversity conservation through the protection of the fauna and flora, the creation and management

of natural reserves and national parks shall be governed by the laws and regulations in force.

(3) The State may erect any part of the national territory into an ecologically protected area. Such an area shall be the subject of an environmental management plan.

Article 65:

(1) Scientific exploration and biological and genetic resource exploitation in Cameroon shall be done under conditions of transparency and in close collaboration with national research institutions and local communities and should be profitable to Cameroon. The exploration and exploitation should be done under the conditions stipulated by the international conventions relating thereto, duly ratified by Cameroon, especially the Rio Convention of 1992 on biodiversity.

(2) An enabling decree of this law shall lay down the terms and conditions under which foreign researchers and Cameroonian research institutions and local communities shall collaborate.

Article 66:

An enabling decree of this law shall determine the historic, archeological and scientific sites, as well as the sites that are of special panoramic beauty, and shall ensure their protection and lay down the conditions under which they shall be managed.

Article 67:

(1) Mining resources and quarries shall be explored and exploited in an ecologically rational manner, making allowance for environmental considerations.

(2) These activities shall be carried out in keeping with the provisions of the laws in force.

Article 68:

(1) The protection of land against erosion and the prevention and fight against desertification are publicly useful. These actions are taken particularly through the planification of the land use and zoning, reforestation as well as the dissemination of ecologically efficient methods of land use.

(2) These activities shall be carried out in keeping with the laws in force and the enabling instruments of this law, as well as the relevant international conventions dully ratified by Cameroon.

Article 69:

(1) Resources shared with other States shall be managed sustainably, and as much as possible, in cooperation with the State concerned.

(2) This cooperation shall be by virtue of the international conventions signed between the States sharing these resources.

Chapter VI

Implementation and follow-up of

Programmes

Single Chapter

Participation of populations

Article 72:

Populations shall be encouraged to participate in environmental management, especially through:

- free access to environmental information, pending the imperatives of national defence and state security;
- consultative mechanisms to take stock of the opinion and contributions of the populations;
- representation of populations within environmental advisory bodies;
- production of environmental information;
- sensitization, training, research and education on the environment.

Article 73:

Environmental education should be introduced in primary and secondary school curriculums as well as in institutions of higher learning.

Article 74:

In order to strengthen environmental awareness in the society and increase the sensitization on and participation of populations in environmental issues, the Administration in charge of the environment and communication, as well as other Administrative units and public bodies concerned shall launch information and sensitization campaigns using the media and other Means of information.

To this end, they shall make use, of the traditional means of communication as well as the traditional authorities and associations working in the field of the environment and development.

PART V

Incentive measures

Article 75:

Any operation contributing to the elimination of erosion and the effective fight against desertification, and to the promotion of the rational use of renewable resources, especially in the savannah zones and the northern part of the country shall benefit from a support from the fund provided for by this law.

Article 76:

(1) Industrial establishments importing equipment to enable them eliminate green house gases like carbon dioxide, chlorofluorocarbons, in their manufacturing process or in their products, or to reduce any form of pollution shall benefit from a reduction of the custom duty on these equipment; the proportion and duration of which shall be determined by the Finance Law as and when necessary.

(2) Private individuals and corporate bodies promoting the environment shall benefit from a deduction on taxable profits according to the terms and conditions laid down by the Finance Law.

Part vi

Liability and sanctions

Chapter I

Liability

Article 77:

(1) Without any prejudice to the sanctions applicable within the framework of penal liability, any person transporting or using hydrocarbons or chemical, harmful and dangerous

substances, or any operator of a classified establishment who has caused body or material damage directly or indirectly linked to the exercise of the above mentioned activities shall be liable for damages without the need to prove his offence.

(2) The reparation of the damage mentioned in (1) of this article shall be jointly borne when the author of the damage proves that the body or material damage is the fault of the victim. It shall be exonerated in the event of a “force majeure”.

Article 78:

When the constituent elements of the offence originate from an industrial, commercial, cottage industrial, or agricultural establishment, the owner, operator, director or manager as the case might be, may be liable to fines or legal fees owed by the authors of the offence, and to the rehabilitation of

The sites.

Chapter II

Sanctions

Article 79:

The following persons shall be liable to a fine of 2,000,000 (two million) to 5.000.000 (five million) CFA francs and a prison sentence of 6 (six) months to 2 (two) years or only one of these two sanctions:

Any person having implemented a project needing impact assessment, without carrying out such assessment;

Any person having implemented a project that does not conform to the criteria, norms and measures spelled out for the impact assessment;

– Any person having obstructed the checks and analyses provided for by this law and/or its Enabling instruments.

Article 80:

Any person who dumps toxic and/or dangerous waste on Cameroonian territory shall be liable to a fine of 50,000,000 (fifty million) to 500,000,000 (five hundred million) CFA francs and Life imprisonment.

Article 81:

(1) Any person having imported, produced, owned and/or used harmful or dangerous substances in violation of the regulations shall be liable to a fine of 10.000.000 (ten million) to

50,000,000 (fifty million) CFA francs and a prison sentence of 2 (two) to 5 (five) years or only one of these two punishments.

(2) In the event of subsequent offences, the maximum total amount of the sanctions shall be doubled.

Article 82:

(1) Any person having polluted, or degraded soils and sub-soils, altered the quality of air and waters in violation of the provisions of this law shall be, liable to a fine of 1,000,000 (one million) to 5.000.000

(five million) CFA francs and a prison sentence of 6 (six) months to 1 (one) year or only one of these two.

(2) In the event of subsequent offences, the maximum total amount of the sanctions shall be doubled.

Article 83:

(1) Any captain of a ship who is guilty of dumping hydrocarbons or other marine
Environmentally harmful

liquid substances into marine waters under Cameroonian jurisdiction in violation of the provisions of this law and its enabling instruments or international conventions relating to the prevention of marine pollution to which Cameroon is a party, shall be ; liable to a fine of 10.000.000 (ten million) to 50,000,000 (fifty million) CFA francs and a prison sentence of 6(six) months to 1 (one) year or only one of these two sanctions.

(2) When the offending boat is other than a tanker, and the gross registered tonnage is lower than 400 (four hundred), the sanctions provided for in sub-paragraph I of this article shall be reduced, while the minimum fine shall not be lower than 1,000,000 (one million) CFA francs.

(3) In the event of subsequent offences, the maximum total amount of the sanctions shall be doubled.

(4) The sanctions provided for by this article shall apply without prejudice to the right to compensation of public or private establishments as well as of persons having suffered damages originating from pollution.

(5) The sanctions provided for by this article shall not apply to dumping by a ship to ensure its own security or that of other ships, or to save human life; neither shall they apply to discharges resulting from damages suffered by the ship without the establishment of any offence against Its captain or crew.

Article 84:

(1) Any person having operated a plant or used a movable object in violation of the provisions of this law shall be liable to a fine of 500,000 (five hundred thousand) to 2,000,000 (two million) CFA frs and a prison sentence of 6 (six) months to 1 (one) year, or only one of these two sanctions.

(2) In the event of subsequent offences, the maximum total amount of the sanctions shall be doubled.

Article 85:

The sanctions provided for by this law shall be supplemented by those contained in the Penal Code as well as in various sectoral laws applicable to environment protection.

Article 86:

The sanction shall be doubled when the above-mentioned offences are committed by an official of the Administration in charge of environmental management, or with their complicity.

Article 87:

The provisions of articles 54 and 90 of the Penal Code relating to stay of proceedings and mitigating circumstances shall not apply to the sanctions provided for by this law.

Chapter III

Establishment of infringements

Article 88:

(1) Without prejudice to the prerogatives of the public prosecutor, and the judicial police vested with general competence, the officials on oath of the Administration in charge of the environment and other Administrative units concerned, especially those of the cadastral survey, town planning, public works, forests, the merchant, mines, industry, labour and tourism services shall be in charge the research and establishment of infringements in keeping with the provisions of this law and its enabling instruments.

(2) The officials mentioned in sub-paragraph (1) above shall take an oath before the competent court, upon the request of the Administration concerned, following the terms and conditions laid down by an enabling decree of this law.

(3) In the exercise of their duties, the officials on oath shall carry their professional card.

Article 89:

Any established infringement shall be the subject of a regular report. Infringements shall be sought for and established by two officials who shall cosign the report. The report shall be authentic until a plea of forgery is introduced.

Article 90:

(1) Any report establishing an infringement shall be forwarded immediately to the competent Administration which shall notify the offender of it. The offender shall have a time-limit of 20 (twenty) days as from the date of notification to contest the report. After this time-limit, any contesting shall be inadmissible.

(2) Where there is contesting within the time-limit provided in sub-paragraph I of this article, the reclamation shall be examined by the competent Administration. Where the contesting is founded, the report shall be closed with no follow-up. Where the contesting is unfounded, and in the absence of a final compromise or arbitration, the competent Administration shall undertake legal proceedings in keeping with the law.

II.1.1. Institutional aspects

The Ministry of Mines and Technological Development which is responsible, among other things, for questions relating to mines was created.

For its better functioning, the ministry relies on the Support and Promotion Framework for Mining Crafts established by Order No. 064 / PM of July 25, 2003 following decision No. 238 / MINMEE / CAB OF April 1, 2003 which created the Support and Promotion Unit for Mining Crafts.

SONAMINE was a light, open-ended, operational and efficient structure, with financial, action and management autonomy. It played a role, on the one hand of coordination, organization, facilitation, support, promotion and development for this socio-economic activity that is artisanal mining, and on the other hand, of interface between said activity, development partner organizations, the private sector, non-governmental organizations and the administration.

It was this unit that was subsequently erected into a Framework for the Support and Promotion of Mining Crafts.

SONAMINE plays the role of coordination, organization, facilitation, support, promotion and development of artisanal mining.

As such, he is responsible for:

- the identification of all existing and potential artisanal mining sites;
- organization at the level of each mining locality, of artisanal miners and cooperative societies or in common initiative groups in accordance with the legislation and regulations in force;
- facilitating the granting of authorizations for artisanal mining to artisanal miners and their socio-professional groups;
- promotion of a gradual evolution of artisanal mining authorizations towards exploration and exploitation licenses.
- facilitation of obtaining research permits or exploitation permits on artisanal mining perimeters;
- facilitating access for artisanal miners and their socio-professional groups, in particular;
- To essential work equipment such as mining shovels, pans, sieves, motor pumps, washing tables and scales;
- modern equipments and technologies ;
- technical assistance with a view to prospecting, extracting, treating, transforming, valuing mineral substances not recovered by artisanal miners, marketing, safety and preservation of the environment;
- facilitating access for artisanal miners and their socio-professional groups to micro credits and microfinance;
- the training and improvement of artisanal miners and their socio-professional groups;
- The channeling of artisanal mining products to formal channels;
- contribution, in conjunction with the ministry in charge of currency, to strengthening Cameroon's gold reserves as part of a partnership between the ministry in charge of mines and the Bank of Central African States;
- contribution to the viability of artisanal mining agglomerations and to improving the living conditions of artisanal miners and neighboring populations;
- promotion of cooperation with the private sector, development partners and non-governmental organizations.

Decree No 2020/749 of 14 DEC 2020 was created to set up the National Mining Corporation abbreviated and referred to as (SONAMINES) which is a public corporation when the state as

sole shareholder. According to its article 3, SONAMINES develops and promotes the mining sector in Cameroon, with the exception of hydrocarbons and quarry materials, and manage the interest of the state in the area. To that end, it is in particular responsible for:

- carrying out the inventory of mining showings, in conjunction with other relevant government services and bodies ;
- conducting studies on the exploration and exploitation of mineral substances, in conjunction with other relevant government services and bodies ;
- carrying out mineral substance exploration, exploitation and marketing activities ;
- promoting the processing of mineral substances ;
- ensuring the implementation of measures relating to the rehabilitation of non-industrial and semi-mechanized mining sites, in conjunction with other relevant government services ;
- acquiring shares in companies involved in the exploration, exploitation, marketing, treatment and processing of mineral substances through contributions, sponsorship, subscriptions, purchase of corporate securities and/or rights, alliance and/or joint-venture ;
- participating in negotiations and monitoring the execution of contracts signed with mining companies, in conjunction with the ministry in charge of mines and other government services concerned ;
- collecting and preserving documentation on mineral substances and mining activities, in conjunction with the ministry in charge of mines ;
- contributing to the promotion of transparency in the mining sector ;
- contributing to the promotion of geological and mining information, in conjunction with the other relevant government services ;
- carrying out all commercial, industrial, capital, real estate and financial transactions directly or indirectly linked to its corporate purpose or that can foster its development.

The World Health Organisation has equally put in place measures and guidelines to evaluate water quality as shown below;

International Organization for Standardization (ISO) standards for detection and enumeration of faecal indicator bacteria in water

ISO standard Title (water quality)
6461-1:1986 Detection and enumeration of the spores of sulfite-reducing anaerobes (clostridia)

— Part 1: Method by enrichment in a liquid medium

6461-2:1986 Detection and enumeration of the spores of sulfite-reducing anaerobes (clostridia)

— Part 2: Method by membrane filtration

7704:1985 Evaluation of membrane filters used for microbiological analyses

7899-1:1984 Detection and enumeration of faecal streptococci – Part 1: Method by

enrichment in a liquid medium 7899-2:1984 Detection and enumeration of faecal streptococci

– Part 2: Method by membrane filtration

9308-1:1990 Detection and enumeration of coliform organisms, thermotolerant coliform organisms and presumptive *Escherichia coli* – Part 1: Membrane filtration method

9308-2:1990 Detection and enumeration of coliform organisms, thermotolerant coliform organisms and presumptive *Escherichia coli* – Part 2: Multiple tube (most probable number) method.

Guideline values for verification of microbial quality

Organisms **Guideline value**
All water directly intended for drinking *E. coli* or thermotolerant coliform bacteria^{b,c} Must

not be detectable in any 100-ml sample **Treated water entering the distribution system**

E. coli or thermotolerant coliform bacteria^b Must not be detectable in any 100-ml sample

Treated water in the distribution system *E. coli* or thermotolerant coliform bacteria^b Must

not be detectable in any 100-ml sample ^a Immediate investigative action must be taken if *E.*

coli are detected. ^b Although *E. coli* is the more precise indicator of faecal pollution, the count

of thermotolerant coliform bacteria is an acceptable alternative. If necessary, proper

confirmatory tests must be carried out. Total coliform bacteria are not

acceptable indicators of the sanitary quality of water supplies, particularly in tropical areas,

where many bacteria of no sanitary significance occur in almost all untreated supplies.

c It is recognized that in the great majority of rural water supplies, especially in developing countries, faecal contamination is widespread. Especially under these conditions, medium term targets for the progressive improvement of water supplies should be set.

- **Guidelines for drinking-water quality**

- criteria for issuing and rescinding advisories;
- information to be provided to the general public and specific groups; and
- activities impacted by the advisory.
- Protocols should identify mechanisms for the communication of boil water and water avoidance advisories. The mechanisms may vary, depending on the nature of the supply and the size of the community affected, and could include:
 - media releases through television, radio and newspapers;
 - telephone, e-mail and fax contact of specific facilities, community groups and local authorities;
posting of notices in conspicuous locations;
 - personal delivery; and mail delivery.
- The methods chosen should provide a reasonable surety that all of those impacted by the advisory, including residents, workers and travellers, are notified as soon as possible.

Boil water advisories should indicate that the water can be made safe by bringing it to a rolling boil. After boiling, the water should be allowed to cool down on its own without the addition of ice. This procedure is effective at all altitudes and with turbid water.

The types of event that should lead to consideration of boil water advisories include:

- substantial deterioration in source water quality;

— major failures associated with treatment processes or the integrity of distribution systems;

- inadequate disinfection;
- detection of pathogens or faecal indicators in drinking-water; and
- epidemiological evidence suggesting that drinking-water is responsible for an outbreak of illness.
- Boil water advisories are a serious measure that can have substantial adverse consequences. Advice to boil water can have negative public health consequences through scalding and increased anxiety, even after the advice is rescinded. In addition, not all consumers will follow the advice issued, even at the outset; if boil water advisories are issued frequently or are left in place for long periods, compliance will decrease. Hence, advisories should be issued only after careful consideration of all available information by the public health authority and the incident response team and conclusion that there is an ongoing risk to public health that outweighs any risk from the advice to boil water. For example, where microbial contamination is detected in samples of drinking-water, factors that should be considered in evaluating the need for an advisory include:

GUIDELINES FOR DRINKING-WATER QUALITY

- reliability and accuracy of results;
- vulnerability of source water to contamination;
- evidence of deterioration in source water quality;
- source water monitoring results;
- results from operational monitoring of treatment and disinfection processes;
- disinfectant residuals; and physical integrity of the distribution system.

The available information should be reviewed to determine the likely source of the contamination and the likelihood of recurrence or persistence. When issued, a boil water advisory should be clear and easily understood by recipients, or it may be ignored. Advisories should normally include a description of the problem, potential health risks and symptoms, activities that are impacted, investigative actions and corrective measures that have been initiated, as well as the expected time to resolve the problem. If the advisory is related to an outbreak of illness, specific information should be provided on the nature of the outbreak, the illness and the public health response.

Boil water advisories should identify both affected and unaffected uses of drinking-water supplies. Generally, the advisory will indicate that unboiled water should not be used for drinking, preparing cold drinks, making ice, preparing or washing food or brushing teeth. Unless heavily contaminated, unboiled water will generally be safe for bathing (providing swallowing of water is avoided) and washing clothes. A boil water advisory could include specific advice for vulnerable groups, such as pregnant women and those who might be immunocompromised. Specific advice should also be provided to facilities such as dental clinics, dialysis centres, doctors' offices, hospitals and other health care facilities, child care facilities, schools, food suppliers and manufacturers, hotels, restaurants and operators of public swimming pools and spas.

Provision of alternative supplies of drinking-water, such as bottled water or bulk water, should be considered when temporary boil water or water avoidance advisories are in place. The protocols should identify sources of alternative supplies and mechanisms for delivery.

Protocols should include criteria for rescinding boil water and water avoidance advisories. Depending on the reason for issuing the advisory, the criteria could include one or more of the following:

- evidence that source water quality has returned to normal;
- correction of failures associated with treatment processes or distribution systems;
- correction of faults in disinfection processes and restoration of normal disinfectant

residuals;

— where detection of microbial contamination in drinking-water initiated the advisory, evidence that this contamination has been removed or inactivated;

guidelines for drinking-water quality

evidence that sufficient mains flushing or water displacement has removed potentially contaminated water and biofilms; and/or

— epidemiological evidence indicating that an outbreak has concluded. When boil water and water avoidance advisories are rescinded, information should be provided through similar channels and to the same groups that received the original advice. In addition, operators/managers or occupants of large buildings and buildings with storage tanks should be advised of the need to ensure that storages and extensive internal distribution systems are thoroughly flushed before normal uses are restored. Water avoidance advisories, which share many features with boil water advisories but are less common, are applied when the parameter of concern, primarily chemical contaminants, is not susceptible to boiling.

II.1.2. Framework texts for artisanal mining activities in Cameroon: exploration and prospecting, extraction, marketing

II.1.2.1. General provisions

"Artisanal mining" is defined as any exploitation whose activities consist in extracting and concentrating mineral substances using manual or little mechanized methods and processes. So, the small mine is part of the mining craft as opposed to the industrial mine which uses large means and in quantity. However, the maximum depth of artisanal mining work is 30 meters within an area of one hectare with a maximum of four hectares for an operator (four permits possible per applicant).

Approval for artisanal mining prospecting

"Research": any process or method of investigation for the purpose of locating and evaluating mineral deposits including prospecting operations, bulk sample and laboratory tests;

"Reconnaissance": set of systematic and itinerant surface investigations by geological, geophysical or other methods using large areas in order to detect signs or concentrations of useful mineral substances;

The exercise of artisanal mining activity is reserved for people of Cameroonian nationality, subject to obtaining an individual prospector's card and / or the artisanal mining authorization issued under the conditions defined by this law.

"The individual prospector card" authorizes any person of Cameroonian nationality to undertake prospecting for artisanal mining operations. It is issued by the departmental delegate of mines with territorial jurisdiction for one renewable year.

Approval for artisanal mining

"The authorization for artisanal mining" gives the right to artisanal mining. It is granted by the provincially competent provincial mining delegate 15 days after submission of the complete file. It is allocated for an area not exceeding 100 m x 100 m and its holder can obtain 04 artisanal mining authorizations, provided that it relates to contiguous land. It gives an exclusive right of establishment, prospecting, exploitation and enjoyment of the products extracted within the framework of the land covered by the title. Its validity is 02 years renewable. This security can be traded.

"Mining title":

- artisanal mining authorization;
- research permit;
- operating permits granted in accordance with the provisions of this law.

"Holder":

natural or legal person whose name is entered in the register as the owner of a mining title; "Operating plant": all buildings, installations, factories, apparatus, equipment, tools or other property of any kind, whether or not fixed to the earth Evolution towards industrial mining The holder of an artisanal mining authorization may at any time apply for an exploration permit or an exploitation permit within his perimeter of artisanal mining. Protection against industrial mining activity.

The area of an exploration permit or an industrial mining permit does not encroach on the area of an artisanal mining authorization, subject to an agreement between the mining craftsman and the industrial mining operator. Marketing of mineral substances from artisanal mining It is done by the commission agents who are legal or natural persons governed by Cameroonian law, subject to authorization from the Minister of Mines and the opening of a purchasing office. The authorization is granted a maximum of 60 days after the submission of the complete file for 04 years renewable. The artisan miner sells his mining product to the commission agent who can resell or export.

It is recommended to locate the purchasing office as close as possible to the operating areas. Environmental provisions the new mining code provides specifications relating to compliance with environmental concerns for artisanal mining.

II.1.2.2. Financial arrangements Individual prospector card

- Grant: 5,000 FCFA
- Renewal: 10,000 FCFA. Authorization for artisanal mining
- Grant: 30,000 FCFA
- Renewal: 50,000 FCFA
- Transfer: 100,000 FCFA
- Surface royalty: 5 FCFA / m² / year
- Ad valorem tax: 3% for precious metals, 8% for precious stones,
- 2.5% for base metals and 2% for geothermal deposits and water. Export and transit authorization: CFAF 50,000 / lot Authorization to open a purchasing office (commission agent)
- Grant: 200,000 FCFA
- Renewal: 200,000 FCFA

The artisanal exploitation of quarry substances is free in the area designated by the territorially competent mining authority, subject to the payment of a municipal tax. In conclusion, the new mining code and the decree adopted for its application make the mining artisan a business leader. All the best practices necessary for the good organization and the good development of the mining industry are compatible with this legal framework. It therefore remains to build the best development strategy for artisanal mining and implement it.

Thus, this activity diversified by its advantages in relation to the fight against poverty and the development of Cameroon, will be able to compete with the industrial mining activity while remaining its promotional support.

Method of exploitation

In the little locality of Djouzami, exploitation of gold is done here principally in two manners: semi-mechanized excavation using excavators and Artisanal exploitation using handy rudimentary materials like shovels, basin and gangling machine. It should be noted that the gold deposits in this area are mostly alluvia. In the Djouzami zone, artisanal mining is carried out not only by its inhabitant but also by people coming from other places like Betaré-oya. Garoua Boulaye and Meiganga.

The soil here is very rich in mineral resources notably, gold and diamond. The areas in this community where these minerals are currently being exploited include the Lokoti, Ngankombol, Bindiba [5]. These mining activities are being monitored by SONAMINE (the Artisanal Mining support and promotion framework). Some of these minning are owned by foreigners and others are open for anyone interested in the mining business.

II.2. Definitions

II.2.1. Artisanal mining (gold panning)

According to the Cameroonian mining code of December 14, 2016 in its chapter II article 4, artisanal mining is defined as: exploitation whose activities consist of extracting and concentrating mineral substances and recovering market products using methods and traditional processes [17]. It should be noted that in Djouzami gold panning is only practiced by the Gbayas as a local population but also by a population from elsewhere (Garoua-boulai, Meiganga, Ngaoundal, Betaré-oya) and the other neighboring villages which surround the locality (source : investigations, November 2020).

II.2.2. Semi-mechanized artisanal mining

The semi-mechanized artisanal exploitation defined by the mining code is: the mining carried out within the framework of an authorization of semi-mechanized artisanal

exploitation of precious and semi-precious substances which uses at most three (03) excavators (shovels) mechanical), a loader shovel and possibly other equipment such as the washing machine for mineralized gravel or concentration of mining products, the use of chemicals in the treatment is strictly prohibited [17].

It is this activity that the South Korean company has been practicing since the end of 2016 until today in the locality according to the departmental delegation of MINIMIDT.

II.3. Geological context of the study area

Due to its location, our study area belongs to the Mbéré ditch. The first geological studies of the sedimentary filling of the ditch showed that:

The presence of metamorphic cement conglomerate known as Borogonous conglomerate "attributed to the Precambrian because of its metamorphism. It was placed in the Birrimian younger than the base complex (presence of pebbles from all Early Precambrian rocks and weak metamorphism).

The presence of non-metamorphic sedimentary formations with the following stratigraphic succession, from bottom to top: conglomerate visible only in the bed of the Mbéré, with rolled pebbles the size of an egg, fine sandstone variegated with clayey areas, flow of basanite, marls and clays (probable), conglomerate of Borogop with elements of diameter between 10 and 30 cm [18].

The lower part of this series is attributed to the Middle Cretaceous. Petrographic data showed that the study area is made up of 3 types of rocks including granite, gneiss and pegmatites [19]. Thus, we specify for each of these elements that:

The granite outcrops in the form of a hill with a low slope of about 10%. It is covered with the gray and yellowish weathering patina. This weathering patina has a thickness of 1 to 2 cm. The rock is made up of crystals, orthosis, muscovite and amphibole. The texture is grainy. Gneiss outcrops in the banks and bed of the Lom River. The gneisses of the Lom river are foliated. This foliation is observed by an alternation of light bands consisting of quartzo feldspathic minerals and a dark band consisting of ferromagnesian minerals. The pegmatite veins are present and show schistositities.

II.4. Mode of placer gold formation

Gold deposits of placer type come from a gold-bearing rock sometimes called "main vein". The minerals are freed from solid rock by mechanical and chemical weathering and then transported usually by water or wind action to the place of deposition [20]. Weathering of primary minerals and transport by streams, where current velocity is low such as in point bar deposits, between ripple marks are concentrated by flowing surface waters either in streams or along coastlines. Sorted and distributed by flow of transporting media such as water, wind and ice. The velocity of flowing water determines whether minerals are carried in suspension or deposited [20]. When the velocity of the water slows, large minerals or minerals with a higher density are deposited. Heavy minerals like gold, of the same size as a low density mineral like quartz will be deposited at a higher velocity than the quartz, thus the heavy minerals will be concentrated in areas where water current velocity is low. Mineral deposits formed in this way are called placer deposits [20, 21].

II.5. Method of placer gold exploitation

II.5.1. The semi-mechanized and artisanal mining of gold in Djouzami

The mining of gold in the locality of Djouzami is carried out in two ways which are; the artisanal exploitation method and the semi-mechanized excavation method.

II.5.1.1. Artisanal exploitation method of placers

Artisanal mining or gold panning does not require enough tools just " the essentials to know : shovels, axes, picks, basins for saddlebags, long saws and sometimes small rectangular wooden washers about 1m long and 0.5 m wide that they use with worn rugs.

Indeed, the artisanal miners do the stiff settling of the washer; the gravel is placed on a traditional table (washer) and water is sprinkled, either with the aid of the pan which gives sand which is washed until a bottom of the pan is obtained which represents a concentrate of heavy minerals in which the gold is found. After recovery, the concentrate is dried and poured onto a tray or paper to separate the gold from other low density elements by blowing and magnetization. The magnet-blowing operation is repeated several times until the final product (gold) is obtained, which above all is avoided.



Photo Mefomdjo , November 2020

Photo 3 : Waste mining



Photo Mefomdjo, november 2020

Photo 4: Artisanal sluice: Washers

The minners go round the different corners where the excavator have abandoned to dig the gravel. They collect gravel next to the company's equipments especially near the automatic washers. They then set up a small slope where they install the carpet downstream. At the raised end, (upstream) of this carpet, they gradually put the gravel that they gradually leach with water to run the mud on the carpet. The latter retains the fine particles in its mesh.

The gold diggers equally dig following the mineralized veins up to a suitable depth after which the mineralized gravel is ground using a grinding machine to reduce the particle size thereby making washing easier. The washing of the gold is done by gold digger with the use of a pan in pits of stagnant water (see photo5).



Photo Mefomdjo, november 2020

Photo 5: Washing using pans

After the exploitation company has dugged using excavators, they now allow local individuals to exploit the remaining ones as arranged (source: investigations).

Here, women and children use pans to separate the sterile from the mineral by stirring the concentrate several times, the aim being to separate the sterile which successively exhaust the mass of the concentrate contained in the recipient. At the end of this step, the mass of the ore obtained is added to a certain volume of mercury (for those using it). A heterogeneous mixture is thus obtained in the form of a ball.

II.5.1.2. Semi-mechanized method of placer mining

Although there are several methods of semi-mechanized operations, in Djouzami the operating company has opted for the excavation method with an excavator. Indeed, it consists in uprooting the trees and other plants present on the site which is an old bed of a watercourse, then excavating using the excavator until reaching the bed-rock. The material is deposited on the sluice, then the settling process begins there by sprinkling the waters of the LOM. The sluice is the semi-mechanized washing device made of an inclined rectangular metal channel with a square section of approximately 30 cm on the side and 4 m in length.

The bottom is lined with transverse cleats (riffles) a few centimeters high spaced 5 to 20 cm from each other which are intended to retain the gold by letting the sands, clays, pebbles and other elements flow out lightly. One end of the sluice is flared to fit into the one before it. The columns of the sluice are of variable length. The sluice, placed end to end, is fixed on stakes with a moderate slope 150 to 200. The head of the column is connected by a channel to a stream, while the other end is closed by one or more grids also called (grizzly). When the installation is in working order, the miners load the raw material on the sluice then the channel is opened and the water flows. As it flows, the water softens, disintegrates and dilutes the ore which is carried along by the slope and the water current while flowing over the carpet. The wooden battens placed across create swirling movements while the grids offer sufficient stopping time for the gold to free itself from its clay matrix and be recalibrated on the carpet. It is at the base of the grids that the nuggets are deposited as seen in photo 6.



Photo Mefomdjo, november 2020

Photo 6: *Semi mechanized gold mining with excavator*

The difference between these two methods (photo 5 and photo 6) is that semi-mechanized mining uses a larger and automatic sluice than artisanal gold mining. Here, the washed materials pass through a 5.7cm mesh which evacuates the waste rock into the overflow. Those with sizes less than 5.7 fall from gravity onto the sluice. The particles of gold and other minerals which are heavier are trapped by the carpet. The concentrated minerals are recovered by washing the carpet in large basins.

II.5.2. Gold extraction and the environment

Gold mining activity is a source of considerable environmental and health impacts and issues, which vary according to the ecological context, the extraction methods and the type of "ore" being extracted. The impacts and stakes are notably deforestation, landscape deformation and modification of the initial state of the mining site, sanitary problems resulting from pollution and/or contamination due to the poor management of liquid and solid mining waste, ecological damages, and hydrogeological modifications. The non-rehabilitation of mining sites leaves many open abandoned pits which are of different depths and heaps of solid rejects which are susceptible to sliding.

There is currently no way to produce significant quantities of gold without environmental consequences. The most frequently cited risks are "uncontrolled release of acid mine effluents (AMS)", releases of heavy metals and cyanides, two types of potentially hazardous substances, for the long or very long term possibly concerning metals and metalloids. Suspended solids (SS) released into streams is also a source of turbidity and potential clogging of spawning grounds, which contribute to degrading aquatic ecosystems [22].

In addition, the exploitation of increasingly poorer ores leads to an increase in the amount of waste accumulated per ton of gold produced, which causes new and constant problems of environmental assessment. For mining geologist Louis R. Bernier, a new risk and release management should take this parameter into consideration [12].

II.5.3. Impacts of mining activities on water quality

Gold mining activities leads to the modification of the hydrogeological operation of the mining basin and have a great deal of impacts on the quality of surface water [21].



Shot Mefomdjo, november 2020

Photo 7: Contaminated water

The picture 7 above shows an artisan who just fetched water from the village drinking spot and how he consumes the water.

From the color of the water, we can immediately deduct that this water is contaminated as the World Health Organization considers potable as water that is colorless. This goes a long way to affect their health.

II.5.3.1. Metal contamination and filtration

Metal contamination is caused by arsenic, iron, cobalt, copper, cadmium, lead, silver and zinc contained in rock exposed in underground mines when in contact with the ground water. The metals are filtered in as the water that moves downstream cleans the top of the rocks. The metals can become stable when the pH level is neutral. On the other hand, the filtration process is accelerated when the pH level is low as in Acid Mine Drainage (AMD) [22].

II.5.3.2. Pollution by chemicals

This type of pollution occurs when chemical agents such as cyanide or sulfuric acid are used to separate the mineral from the ore. This chemicals spill or filter into nearby water bodies. These chemicals can be very toxic to wildlife.

II.5.3.3. Erosion and sedimentation

Gold mining is an important source of soil erosion due to the fact that it leads to the exposure of large surfaces. During the extraction process, large volumes of soil up to several meters (15 meters according to the norms) are displaced. This heaps of soil are washed and the particles driven in to the water course by heavy rainfall.

Without adequate prevention and control strategy, soil erosion can result in spills into streams, rivers and lakes. Excessive sediment spillage can block rivers, smother vegetation, destroys wildlife, destroy flora and aquatic life [23].



Shot Mefomdjo, november 2020

Photo 8: *Hips of soil*

From picture 8 above, we can observe mountains of soils dugged with excavators by the exploitation company after the vegetation has been destroyed. These hips of soil represent a great danger for the artisans as they can serve as aggression point since they hinder visibility.

II.5.3.4. Increase turbidity

The transportation of soil particles from the mining sites into the water course due to erosion increases its turbidity and the rate of suspended solids. Hence the penetration of sunlight into the water is hindered which affects the proper growth of aquatic plants. The increase in turbidity and suspended solids decreases the amount of oxygen in water which affects aquatic life.

Depending on the quantity of suspended solids brought about by the mining exploitation and the river's kinetics, the increase in turbidity can extend from a few meters to a few kilometers downstream to the mining site.



Shot Mefomdjo, november 2020

Photo 9: Increase in turbidity

This turbidity enables us to qualify visual information on the color of water. Turbidity of water is due to the presence of finely divided suspended matter: clays, silts, grains of silica, organic matter, etc. it gives an idea of the content of colloidal matter of organic or mineral origin, linked to transparency.

II.5.3.5. Contamination by mercury

The use of mercury to recover gold is forbidden in Cameroon but many gold extraction companies still use this method in a clandestine manner. During the recovery operation about 40% of the mercury escapes into nature in the form of metal ball or vapour. For every gram of gold recovered, two grams of mercury escapes into the atmosphere [24]. The mercury rejected into nature can be drained into the water course and disbursed in sediments or it can be transformed to an organic component called methyl mercury by the help of bacteria. This organic component can enter into the food chain causing serious health issues. Hence there is the risk of direct exposure (by inhaling) or indirect exposure (through the food chain) to mercury by population found around the mining site.



Shot Mefomdjo, november 2020
Photo 10: Contamination by mercury

After washing, the particles obtained are put in a dish containing mercury which is later turned around in a circular manner so the particles of gold could be attracted to it forming bulls as shown in the picture above while the remaining substances are thrown away. Thus, mercury acts as a magnet to gold.

II.5.3.6 Contamination by metals

The presence of dissolved metals in surface water results from the washing and degradation of the parent rock and the soil. Metals such as Lead, Iron, Zinc, Nickel, Cadmium whose minerals are generally associated with gold. These metals are washed by rain water and transported to the surface. These metals are harmful and usually present in great quantity in the water found in exploitation sites.

Conclusion

This chapter consisted of the generalities in which some mining law and decrees in Cameroon were mentioned. The mining activity was also described which consist of artisanal and semi-mechanized mining and some of its impacts on the environment mentioned. The next presents the results and discussion of our work.

CHAPTER 3: RESULTS AND ANALYSES

This chapter is reserved for the presentation of the results of the different methods employed in this work such as: the field investigation, water sample analysis and the evaluation of the impacts on all the environmental and social aspects of Djouzami. We will also propose an Environmental and Social Management Plan (ESMP).

III.1. Results from water analysis

This section presents the results from the analysis of the water samples collected in the Djouzami mining site which is our case study zone. The aim is to illustrate the correlations that exist between the mining activities and the health of the population.

III.1.1. Water sampling map

In order to establish a correlation that could exist between the health problems of the population of this locality and water found either on the mining site or the drinking point of the village, we had to take some water samples.

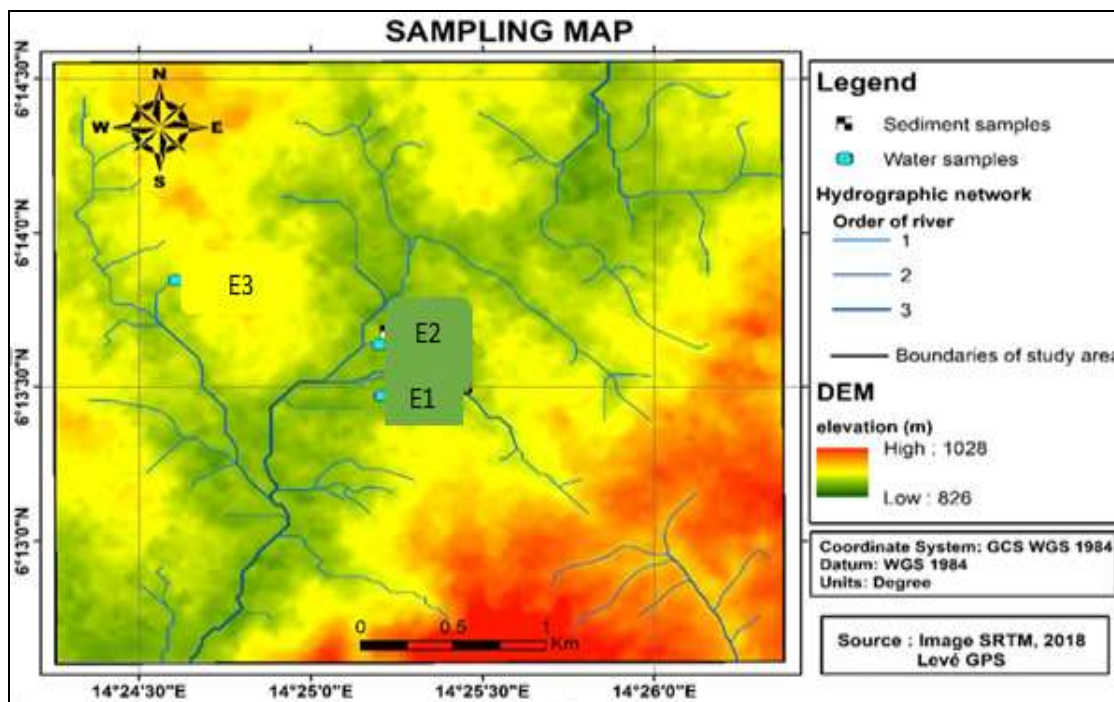


Figure 7: Sampling map [5]

Three water samples were collected at different points of the site (see figure 7).

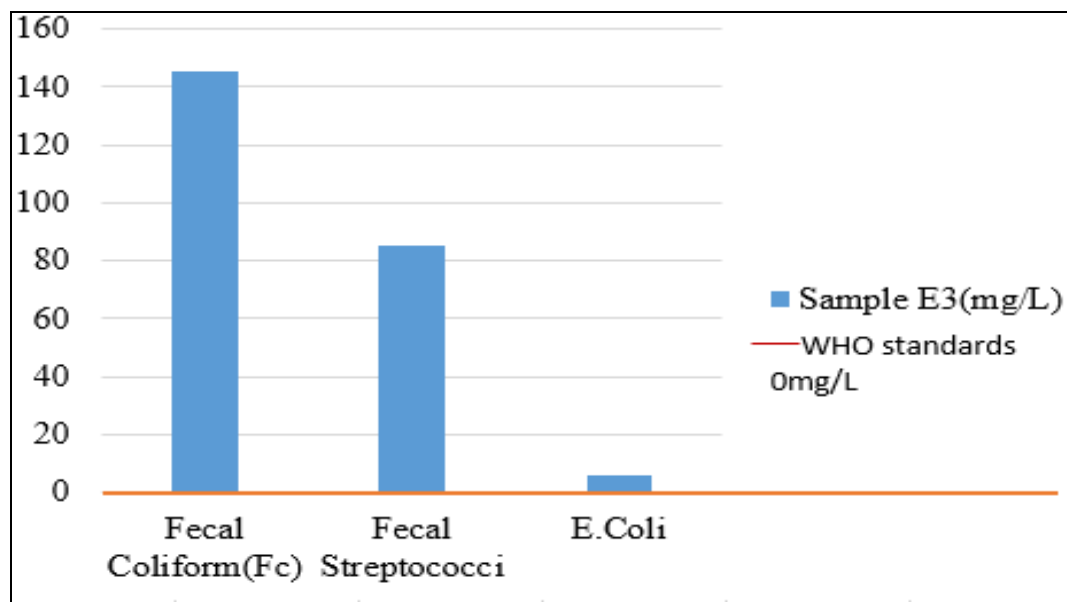
- E1 corresponding to the washing waste water and collected from the water flowing directly from the gold washing machine.
- E2 collected from the river used by the villages for washing.
- E3 collected from the main drinking borehole.

The sampling campaign was done on a sunny day and the flow of the River was relatively average. The water samples were taken using 1.5-liter plastic mineral water bottles (Table 2) following the water-sampling guide of (Loire-Brittany water agency) in particular:

- a point sample, that is to say at a given point, at a given depth and at a given moment;
- a manual method using a suitable container;
- sampling is done 30cm beneath the water surface;
- rinsing the bottle and its cork 3 times with the water to be sampled;
- drain the bottle by shaking the neck downwards;
- immerse the bottle in the water with the neck facing downwards;
- turn the bottle over, leaving it inclined at an angle of about 45 °, with its collar in the upper position, facing the water current;
- fill the bottle slowly without bubbling;
- rinse the stopper by shaking in the water of the river;
- Close the bottle carefully, but strongly so as not to trap air in bubbles.

Microbiological analyses

The microbiological analysis done in our studies is the D1 type which is suitable for consumable water [25]. The microbiological quality of water depends on the presence of bacteria, faecal contamination (fecal coliform, fecal streptococci, *E. coli*) and salmonella. The microbiological analysis for sample E3 collected from the drinking borehole was carried out in the microbiology laboratory of the University of Yaoundé 1. The result of the microbiological analysis is summarized in figure 8.



Source: Investigations, November 2020

Figure 8: Results of microbiological analyses

This results show that the value of fecal coliform analyzed is 145 followed by that of fecal streptococci which is 85 and E.coli which is 6. All these values are above the World Health Organization requirements for drinking water. This is due to an important human presence and activity around and inside the river.

III.2. Result of field investigation

III.2.1 Analysis of questionnaires and interviews

The field questionnaires were carefully treated in an orderly manner according to the different categories of people that were interrogated and the milieu (human, physical and biological) being investigated. Each response from the questionnaires and interviews together with the field observations was analyzed to identify the different impacts.

III.2.2. Results of the identification of impacts resulting from the site.

The interaction between the activities of the semi-mechanized artisanal gold mining and the natural and human environment of Djouzami is illustrated using the Leopold interaction matrix. The result is index in the table 6 below.

Table 7: Leopold matrix table of interaction of impacts and the components of the environment

ACTIVITIES		Human Environment								Physical Environment					Biological Environment			
		Agriculture	Town planning	Pollution	Health	Nuisance	Economy	Quality of life	Social aspects ;drugs,alcohol	Natural risks	Water	Climate	Soil	Basement	Fauna	Flora	Landscape	Natural space
Mine development phase	Deforestation, Construction of sheds and huts	-						-		-	-	-	-		-	-	-	-
	Digging of exploitation wells	-			-				-	-	-		-	-			-	
Exploitation phase					-				-	-	-		-	-				-
Phase of mineral treatment	Digging, settling, winnowing, sieving,	-			-	-			-		-		-					

Evaluations of the environmental and social impact of gold mining in the locality of Djouzami

	washing and drying																	
	Panning	-		-	-		+	+			-							
	Cyanide attack or amalgamation	-		-			+	+			-		-	-	-	-		-

Source : investigations

Legend : - negative impacts, + positive impacts

Table 6 which presents the different impacts identified from mining activity in Djouzami is based on three elements of the environmental component namely ; the human, physical and biological components. Thus, we note that the human environmental one has eight affected sectors against five for the physical and four for the biological environment. Therefore this activity has more consequences on the population. In addition, this identification made for these impacts already presents an enormous negative nature compared to the positive ones.

III.2.3. Description of the impacts of gold mining on the different aspects in Djouzami

This part of the work consists of a precise description and interpretation of the impacts identified in the Leopold's Matrix of interaction starting whether they are positive or negative.

III.2.3.1. Impacts on the local population and their activities

The mining of gold in Djouzami has a great deal of effects on the lives of the local population.

Negative impacts

The results of our investigation revealed that the population of Djouzami which once lived a quiet life rich in culture and diversity changed with the coming of mining activities. A population which relied on agriculture as their primary source of livelihood is now massively involved in the gold mining business to a point where there is now a drop in agriculture products in the local market. Most villagers have abandoned their houses for the mining site. These mining activities have also led to a lot of household problems as most families have turned out to be gold miners with each member of the family giving more of their attention to the mining business rather than to their family duties. Our investigation showed that many women involved in gold mining have abandoned their wifely and motherly duties. Women were seen with their babies on their backs for long hours under the sun and rain in search for gold. There exists conflicts between the Chinese and the gold panners on the limited places where the artisans are allowed to exploit their own gold. The villagers mostly complain of the non-participation of the operators to their development and their wellbeing.

According to our investigations, most youths appreciate this new activity to the detriment of their education. A lot of alcohol and drugs are consumed in the mining sites; a lot of promiscuity is also registered with many young girls turning to prostitution. Our investigations also revealed that this locality has experienced a general increase in birth rate since mining activities started. Also many cases of young girls forced to settle with their artisan partners without any bride price as a result of unwanted pregnancies.



Shot Mefomdjo, november 2020

Photo 11: *Women and children on mining site*

On these mining sites, we mostly find young girls and their babies as shown in the picture above. They do this all day long at the detriment of their studies while expecting to sell the quantity of gold obtained to gold collectors so as to feed their families.

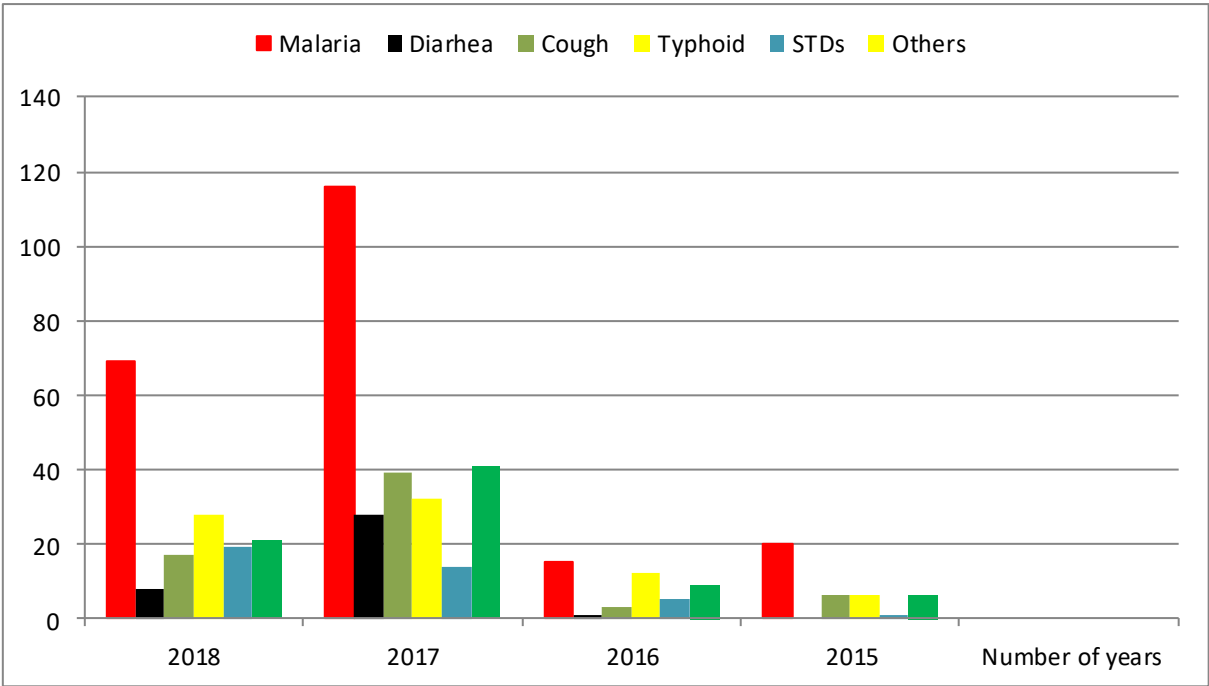
Positive impacts

The mining activity in this locality has also been beneficial to the population. A huge part of this population has found themselves jobs in the mining sites. The livelihood of the artisans has been improved due to revenues from the direct sales of gold and other related activities. This activity has also led to inter-marriages between the villagers and artisan from different regions.

The coming of gold mining has brought about development in the locality such as the opening of the Djouzami primary school and the construction of drinking boreholes.

III.2.3.2. Impacts on health

The field investigations together with information gotten from the LOKOTI district hospital show that a good part of the population mostly suffer from water born diseases (typhoid, diarrhea, stomach problems, amoebiasis etc), malaria and water related skin diseases. These health issues are due to water around the mining sites which act as a breeding space for mosquitoes and the non-use of mosquito nets. Also due to the lack of toilets, spending long hours in water during panning and use of contaminated water for bathing and household washing. The health registrar at the district hospital revealed a remarkable increase in the number of HIV cases with up to 85% percent related to mining activities. This is due to the high level of promiscuity around these mining sites. Also, those carrying out semi mechanised exploitation are mostly single men who sleep around with the little girls around the site who in turn sleep around with others. Thus, spreading STD's. It was observed that the workers lacked individual protective equipment (IPE) which exposes them to health and safety risk. The only IPE provided to them by the companies they work



for were boots. Figure 9 designates the distribution of diseases in this locality.

Source : investigations, november 2020

Figure 9 : Diagram of Impacts on health

To this effect, the impact on the health of the artisanal mines and the rest of the mining village are among the most important problems for the communities which depend on this mine because even after the exploitation, workers will continue to suffer from the impacts of this activity for a long time.

It should be noted that according to the staff of the operating company at the level of health, no effort is made on the part of their employer. They are submitted to risk of illness and do not benefit from any support.

III.2.3.3. Impacts on the ecosystem

Gold mining in the site where our studies was carried out has led to landscape destruction due to the displacement of large quantities of rocks and sterile which has created large artificial lakes (see photo 12) and pits with stagnate water. It has also lead to the destruction of the vegetation cover and soil degradation.



Photo Mefomdjo, november 2020

Photo 12: *Large artificial lakes*

The cutting down of trees has led to the loss of some key forest objects leaving it sterile and poor in vegetation. The noise from the installation and manipulation of machines have chased away wildlife

From the pictures above, we observe that gold mining has led to the disappearance of cultivable, fishing and hunting space that were formerly present. Thus, the forest which covered the village becomes more and more the shadow of itself while sacred and important objects are disappearing: « they have destroyed our bridge that used to help us cross the LOM constructed by our grandparents » declares a resident.

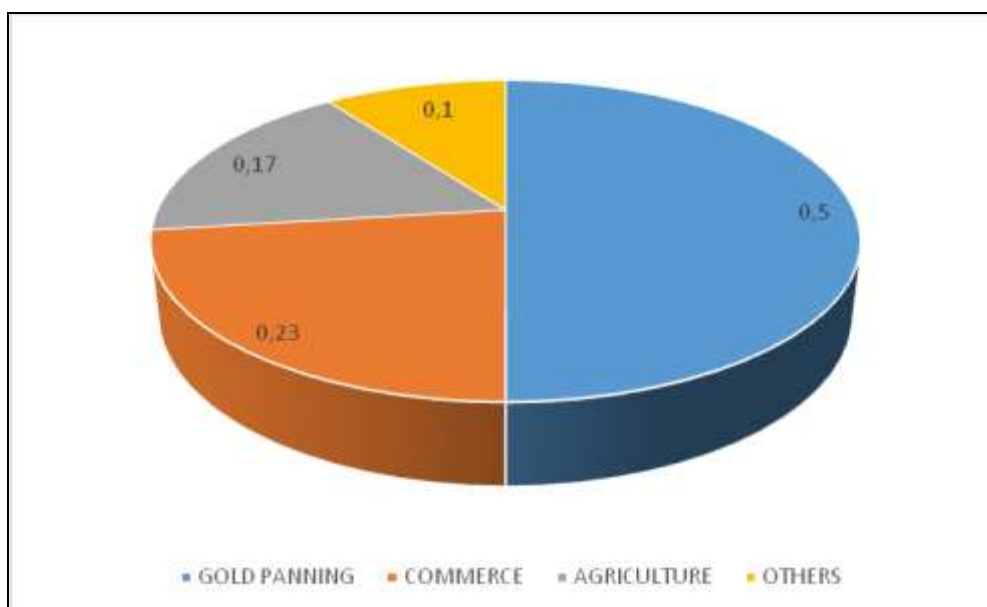
The effluent from the washing of gold is deposited in to the river (see photo 13).



This effluent contains chemicals and heavy metal vectors which can lead to water and soil pollution. Sulphide mining residue when exposed to air or water can generate acidic effluent thereby causing water and soil pollution. As such, it renders the soil sterile, inadequate for agriculture and animal husbandry and the waters equally unsuitable for drinking and water species.

III.2.3.4. Impacts on the economy

Gold mining plays a massive role in the economy of our zone of study. The revenue generated from this activity contributes to the reduction of poverty in the rural areas. The foreign companies have recruited the local population and people from the other regions of Cameroon. The employees' earn a monthly salary depending on their respective task. As for the gold panners. Some associate with their friends, others with their family and some work individually. Their revenue comes from the direct sales to gold collectors. Gold mining has also lead to the birth of other businesses such as the renting of mining machines and equipment to artisans and small scale commerce. Figure 10 shows the repartition of different activities in Djouzami.



Source: investigations, **november 2020**

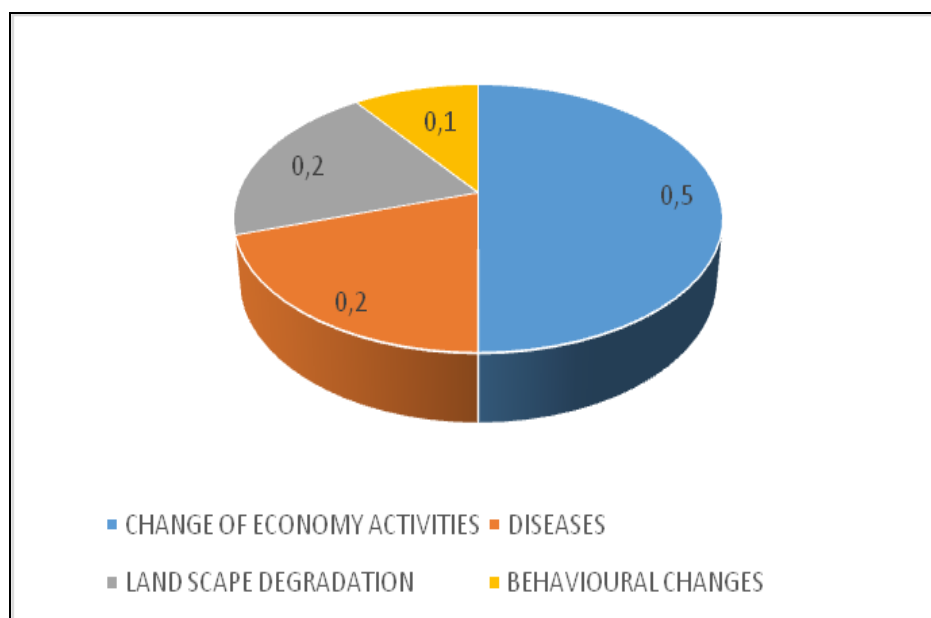
Figure 10: *Different economic activities in Djouzami*

From figure 10, it can be observed that gold panning is the principal activity of the population of Djouzami (50%) followed by commerce (23%) and agriculture which has almost been abandoned (17%) talk less of other activities such as animal husbandry, etc.

III.2.3.5. Impacts on security

This locality is faced with insecurity problems due to its activeness in mining activities. In October 2016 a murder case of a business man and his driver on their way from Djouzami for a regular business trip was reported. They were assassinated by armed robbers from the bush. This region is threatened by rebels from the Central African Republic with whom it shares its borders. But security measures have been put in place by the mining companies and the government.

In a general manner, the summary of the assessment of the impacts of gold mining in Djouzami on the socio economic and environmental components is illustrated in the figure 11 below.



Source : investigations, november 2020

Figure 11: Gives a summary of the impacts of semi mechanized artisanal gold mining in Djouzami

A change from their former economic activities is remarkable in this locality (50%). Thus, reducing their standards of living. The rush towards gold mining has led to massive landscape degradation (20%) and health issues with the increase in the rate of diseases (20%). Behavioural changes are also a consequence of gold mining in Djouzami as women and children have abandoned their marital duties and studies in search of gold.

III.2.4. Ishikawa or cause and effect diagram

The Ishikawa diagram also called cause and effect diagram is used to interpret the impacts of this activity. It serves to represent the relation that exists between an effect and all the causes of a problem. It is useful to draw a list of variable potential causes of a problem.

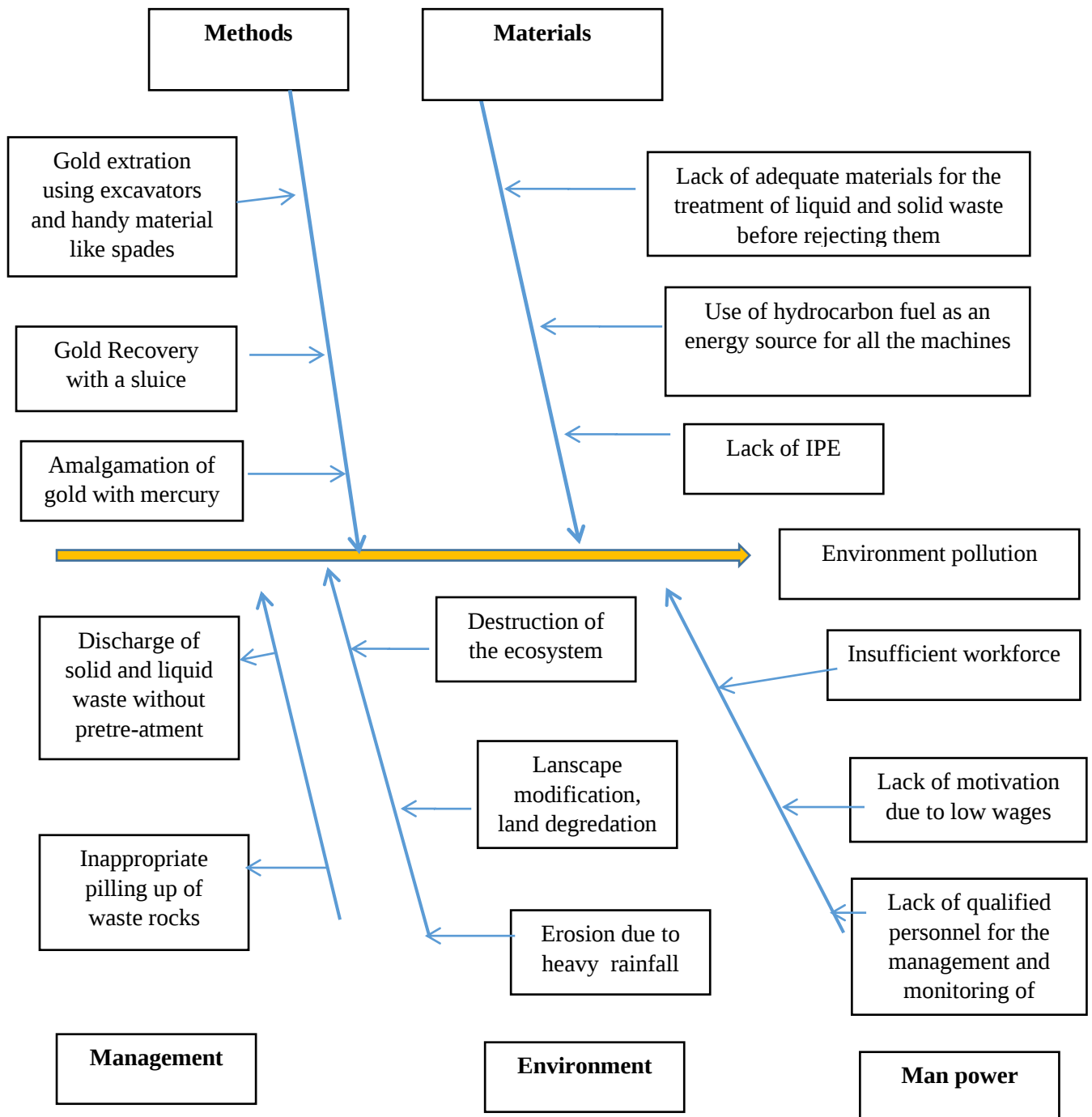


Figure 12: Illustrates the results of Ishikawa diagram

From the diagram above, the methods employed for gold mining in our work included:

- gold extraction using excavators and handy materials like spades,
- gold recovery with a sluice,
- amalgamation of gold with mercury which causes water pollution and health issues.

Materials

- There was the lack of adequate materials for the treatment of solid and liquid waste before rejecting them which causes soil and water pollution,
- The use of hydrocarbon fuel as an energy source for all the machines which causes atmospheric pollution,
- The lack of individual protective equipment which exposes the workers to risk.

Management

- No control when it comes to the piling up of waste rock during excavation,
- No control on how to discharge solid and liquid waste

Environment

The mining activity led to the destruction of the ecosystem, land degradation, landscape modification and erosion.

Man power

There was insufficient work force, lack of motivation due to low wages and lack of qualified personnel for the management and monitoring of environmental resources.

All of the above are causes of environmental pollution.

Due to a high concentration of gold ore in the subsoil of the locality of Djouzami and the profitability of its exploitation, the rush towards gold continues to grow. It emerges from the previous Ishikawa diagram above that the main activities that are sources of environmental pollution are gold mining activities (excavation, digging of river beds), the discharge of liquid wastes resulting from washing and of the enrichment of gold by amalgamation. The use of hydrocarbons for the operation of machinery during operations can also be a source of water pollution. In addition, the lack of an effective control mission for environmental practices on the operating sites is the cause of a carelessness that could be a major danger for the quality of

surface water in the locality. The lack of knowledge of workers and artisanal miners in relation to the risk of water pollution and its effects on health and the environment could also be a determining factor in the future of water quality in the Djouzami area.

This diagram therefore describes the short comings of the method of exploitation being used.

III.3. Results of the assessment of the impacts listed

III.3.1 Characterization and Evaluation of Impacts.

Artisanal and semimechanised gold mining in Djouzami has many impacts on the populations according to the identifications, correlations and analyzes of the surveys.

There is therefore a need to determine the strength of these impacts in order to find solutions such as environmental measures to reduce negative impacts and, to an extend possible enhance positive impacts (table 7).

Table 8: Ranking of impacts according to their criticality

Component of the affected human environment	Impacting activities	Designation of the identified impact	Characterisation Parameters						Evaluation
			Nature	Intensity	Scope	Duration	Occurrence	Reversibility	Absolute importance
Health	Pollution survey of waterways (chemical products, mud)	Degradation of the state of health of artisanal miners and surrounding populations	▽	3	2	3	3	2	2,6
	Waste management Transportation of aggregate	Risks of increased pregnancies and the prevalence rate of STDs	▽	3	2	2	2	1	2
Impact on revenue	Sae of gold, development of side economic activities	Employment opportunities and revenue increase	△	3	3	2	3	2	2,6

Education	Presence of several children on the mining site	Low enrollment rate for young children in school	▽	3	2	2	3	2	2,4
Quality of life	High implication of women in mining activities	Neglect of household chores and lack of education and monitoring of children	▽	3	1	3	3	3	2,6
	Increase in revenue	Improvement of living conditions	△	1	2	1	1	1	1,2
		High rate of consumption of alcohol, drugs, hijacking of young girls and prostitution	▽	3	2	2	3	2	2,4
	Recruitment of local staff in the company	Social conflict or tension	▽	2	1	2	2	1	1,6
Living environment	Absence of restoration of the environment after exploitation, felling of trees and surface stripping								
		Ugly landscape	▽	3	2	3	3	2	2,6
		Noise pollution	▽	2	2	1	1	1	1,8

Source : investigations, november 2020

Legend : Positive Impacts △

Negative Impacts ▽

The rating legend is as follows:

- (2,4-3)= very important impact (major)
- (1,7-2,3)= impact of average importance
- (1-1,6)= less important impacts(minor)

The characterization and evaluation of the impacts of artisanal and semi mechanised gold mining on the populations of Djouzami presented in the table above reveal that mining has many impacts on the human population. Thus, in general, the latter are considered of major importance because they are very significant (68, 64%) against 18, 18% which represent both non significant impacts and significant impacts. To this effect, positive impacts represent 50% of minor impacts and only 14, 29% of major impacts, the rest being negative.

With the aim of determining the priority impacts to be solved, i.e. those which have the primacy of consideration and to evaluate the levels of risk. The interpretation of this characterization led us to necessarily draw up a classification of the designated impacts according to their degree of criticality. It should be noted here that it is this level of criticality of each impact that guides and determines the different measures proposed to solve the problems.

The values of the absolute importance are rounded up to have whole numbers.

III.3. Impact prioritization

This enables the classifications of impacts according to the degree of criticality on the environment as shown in the table 8:

Table 9: Impact prioritization

Impact	Nature of impact	importance	Probability of occurrence	criticality	Degree of urgency
Landscape modification	-	3	3	-9	Priority
deforestation	-	3	3	-9	Priority
Pollution of water resources	-	3	3	-9	Priority
Diseases	-	2	3	-6	secondary
Sound pollution	-	2	3	-6	secondary

Soil pollution	-	2	3	-6	secondary
Loss of biodiversity	-	2	3	-6	secondary
Disturbance of the flow of surface water	-	2	2	-4	Final
Soil erosion	-	2	2	-4	Final
Effluent production	-	2	2	-4	Final
Loss of pasture and Agricultural soil	-	2	2	-4	Final
Social conflicts	-	1	2	-2	Final
Employment	+	1	3	+3	Negligible

Source : investigations november 2020

From the table above, priority should be given to almost all the impact related to mining activity as almost all these impacts have a negative criticality. But while dealing with attenuation measures, we have to start by reducing its impact on landscape modification, deforestation and pollution of water since their degree of criticality is very high (-9), followed by impacts on diseases, noise pollution, soil pollution and loss of biodiversity with average degree of criticality (-6). Those with less degree of criticality (-4,-2) should be treated lastly.

III.4. Risk study

In the mining law N 98/015 of 14th July 1998 gold mining is classified as a dangerous an insanitary activity and it is ranked amongst the category A activities at risks. Table 9 exhibits the different risks identified in the study zone.

Table 10: Risk identification

Environment	Risks identified
Fauna	Risk of the biodiversity
Flora	Risk of flora eutrophication due to increase in suspended solids
Landscape	Risk of fire incidence due to the presence and use of inflammable substances
Humans	
Mine workers	Risk of accident, risk of shock, risk of falling objects and risk of health condition from the manipulation of machines Risk of diseases due to unhygienic working conditions Risk of landslide Risks of intoxication from the use of chemicals
Local population	Risk of consumption of underground water polluted with chemicals by the villagers and risk and risk of water-borne diseases from the consumption of bacteria infected water Risk of unwanted pregnancies and increase rate of HIV /STDs

Source : investigations november 2020

This table summarizes the long-term impacts on the components of the ecosystem. it reveals that there will be risk of a complete loss of biodiversity, flora eutrophication, fire incidence, accidents, landslides and unwanted pregnancies if care is not taken.

This chapter aimed at presenting the results of the evaluation at the level of the gravity of impacts of artisanal and semi-mechanized exploitation of gold on the environment and the populations with the aid of certain tools such as Leopold's matrix, Gaetan et Raymond's grid and the Ishikawa diagram.

CHAPTER 4: DISCUSSION AND RECOMMENDATIONS

In this chapter, we are going to discuss on the results of the different methods used and some recommendations.

IV.1. Discussions

The results presented in this work are being obtained with the help of documents, direct field observations, investigations with the help of questionnaires answered by the local population and the analysis of collected samples. It is said to say that the miners in the Djouzami site do not respect the line 1 of article 17 of the environmental management law N 96/12 of 5th August 1996 [26], also the lines 1 and 3 of article 137 of the mining law N 2016/017 of the 14th December 2016 [27].

According to the Ishikawa cause and the effect diagram which effectively describes the short comings of the method of exploitation being used and the fact no ESIA was carried out before exploitation, it shows that the effects of mining is more negative than positive in the locality of Djouzami in many aspects.

IV.1.1. Discussion on the human aspect

Our field investigation results prove that there is an increase in the rate of socio-economic development in the locality of Djouzami. Semi mechanized and artisanal gold mining is a remunerative activity for both the mine workers and the artisans. This activity has led to the birth of other related activities such as small scale commerce. A good number of the artisans have bought their own properties with the money they earn from this activity. Our studies show that the revenue gotten from the gold mining is hardly reinvested in other businesses despite all the efforts put in place by SONAMINE to sensitize the gold miners on this subject. Thus we can say that with the life style of the population involved in artisanal gold mining fluctuates with time depending on the gold productivity and market. It is very important to ensure that gold mining is carried out in a suitable manner.

IV.1.2. Discussion on the health aspect

Gold mining proves the emission of mercury in the air and in water; it also causes increase in turbidity. It is also responsible for some health problems in the site and the village as well. The water sample analysis shows that the drinking borehole though looking clean is contaminated by bacteria and should be treated before consumption to avoid waterborne diseases. The high rate of suspended solids and turbidity in the rivers of this locality is a source of waterborne diseases. This river is contaminated with chemical elements from the mining site. It also contains heavy metals which can get into the food chain causing severe health issues. The high rates of malaria infection in this locality can be attributed to the presence of open pits containing stagnant water which acts as a breeding space for mosquitoes. The consumption of drugs and alcohol is due to the hard work involved in gold mining. STDs are common in this locality notably HIV and Chlamydia and are often associated with gold miners. The use of mercury to amalgamate gold is a source of long-term health condition to those who manipulate it. In 2003, Africa economic commission has carried out test on gold recovery without the use of mercury and proposed other methods of recovering up to 99.8% or same amount of gold recovered with the mercury [28].

IV.1.3. Discussion on the environmental aspect

Gold mining in the Djouzami mining site makes use of a very large surface area which is the principal cause of landscape modification. In order to access gold excavation is done up to 15 meters deep which also causes the displacement of large volume of rocks and sterile. Gold mining in this zone also involved the cutting down of trees, soil excavation and deviation of the river course. It has also led to the destruction of the vegetation cover and soil degradation. This activity also leads to the displacement of some animal and plant species. These can be mitigated by taking suitable measures to preserve some rare species.

The solid and liquid waste such as waste oil from machines is a source of soil pollution. The use of chemical products such as mercury is also a potential source of soil pollution. The erosion of hills of soil during the raining season increases the amount of suspended solids and the turbidity in the Lom river. This can be seen from the results of the water samples analysis.

These impacts can be corrected or mitigated by the recycling or treatment of mining effluents before final deposition and also by the restoration or rehabilitation of the site.

IV.1.4. Attenuation Measures

Taking into consideration the impact prioritization, certain environmental actions aim at solving these problems either by eliminating the impact completely, reducing the effect of the impact or compensation for irreversible impacts. The environmental actions are presented in the table 10.

Table 11: Environmental actions

Receiving environment	Potential impact	Nature and absolute significance	Mitigation measures
Fauna and flora	Landscape modification	Negative and average	Rehabitation of site.
	Loss of biodiversity	Negative and average	Waste management plan.
	Deforestation	Negative and major	Filling of pits.
	Loss of agricultural land and pasture	Negative and minor	Protection of rare species. Afforestation. Compensation of farmers and breeders
Soil and air	Air pollution	Negative and minor	Wear IPE
	Soil pollution	Negative and average	Use of a geo membrane to prevent infiltration.
	Production of solid waste and effluents	Negative and average	Solid and liquid waste management plan on the site. Sensitization on how to manage waste.

Water resources	Water pollution Disturbance of the surface water flow	Negative and major Negative and average	Treat all waste before rejecting them. Create drainage système
Health	Diseases	Negative and average	Hygeine sensitization
Employment	Job creation	Positive and minor	Creation of micro finances to help manage the revenues of the workers

Source : investigations, november 2020

From the information above, we can clearly deduct that the implementation of these measures will be very costly, difficult and take a lot of time. Reason why these miners often do it in a clandestine manner leaving behind them an environment different from what they previously met. Thus, in order to carryout gold exploitation, the company or individuals willing to do this should be of good faith or conscious of their actions.

Risk evaluation and reduction measures

The Table 11 shows the evaluation and reduction of certain risks related to gold mining activities in the study zone.

Table 12: Risk evaluation and mitigation measures

Risk	Risk analysis				Object of the compensation of action
	Magnitude (M)	Probability (P)	Criticality (C)	Compensation measures	
Work accidents	3	2	6	The gold miners should be given first aid training Training on how to handle dangerous chemicals	Rescue victims Avoid accidents
Social risk	3	1	3	Prohibition of children working in the minning site Put in place a cell to help manage gold miners/ native conflicts	Encourage education Create a safe and amicable environment
Spillage of toxic substances	3	3	9	Use IPE	Avoid injuries

				create a safe zone for the use and storage of toxic substances	Avoid the spread of substances in sensitive environment
Professional diseases	2	3	6	Sensitization on the proper use of IPE Putting in the place of sick fund	Reduce the risk of diseases Take immediate care of the risk
Fire incidence		2	4	Sensitization on the use of IPE Training on how to handle dangerous substances	Protection of miners against fire incidence avoid accidents

Source : investigations, november 2020

Risks on spillage of toxic substances have a very high criticality (9), so, should be highly controlled or monitored followed by risks on work accidents and diseases (6) and later on fire incidence (4) and (2) for social risks.

IV.1.4. Proposition of an environmental and social management plan (ESMP)

An ESMP is proposed to ensure the protection of the environmental and social aspects of this locality. The proposed ESMP is summarized in table 12.

Table 13: Proposed ESMP

Receiving environment	Objective of action	Impacts	Executing actors	Monitoring actors	Monitoring indicators	Execution plan
Water	Prevent underground and surface water pollution	- pollution of water resources - exhaustion of water resources	Artisans	The village chief and his collaborators	Report of environmental activities	Before mining exploitation
Soil	Protect the soil from toxic substances	Erosion Soil pollution	Artisans	The village chief and his collaborators	Report of environmental activities	Before, during and after mining activities in the site.
Flora and fauna	Mitigate the impact of the destruction of flora and fauna life	Deforestation Destruction of topographic	Artisans	The village chief and his collaborators Delegation	 visit to the	Before, during and after mining activities in the site.

Evaluations of the environmental and social impact of gold mining in the locality of Djouzami

	Minimise landscape degradation	relief		of environment	site	
Health and security	Avoid public health and safety endangerment	Proliferation of diseases/STDs /HIV Deaths and insecurity Degradation of the health of the gold miners and the local population	NGO community	The village chief and his collaborators	Rate of insecurity Prevention Rate of diseases	Before, during and after mining activities in the site.
	Job creation	Unemployment	Artisans	The village	Survey of the	Implemented

Evaluations of the environmental and social impact of gold mining in the locality of Djouzami

Economy	and the amelioration of livelihood of the artisan	after the mine closure		chief and his collaborators	riverine population Employment rate from gold mining	progressively
Education and quality of livelihood	-Integrate children in the educational system Sensitisation on livelihood Sensitisation on family responsibility	Low rates of child education Increase in the rate of alcohol and drug consumption Marital conf	NGO The local Community The village chief and his collaborators	The village chief	Number of children registered in schools Number of mine workers registered in micro finances Number of women involved in	Before and during mining exploitation.

					mining activities	
--	--	--	--	--	----------------------	--

Source : investigations, november 2020

World Health Organisation proposed actions

Identifying local actions in response to microbial water quality problems and emergencies

During an emergency in which there is evidence of faecal contamination of the drinking-water supply, it may be necessary either to modify the treatment of existing sources or to temporarily use alternative sources of drinking-water. It may be necessary to increase disinfection at source, following treatment or during distribution. If microbial quality cannot be maintained, it may be necessary to advise consumers to boil the water during the emergency (see section 7.6.1). Initiating superchlorination and undertaking immediate corrective measures may be preferable where the speed of response is sufficient to prevent significant quantities of contaminated water reaching consumers. During outbreaks of potentially waterborne disease or when faecal contamination of a drinking-water supply is detected, the concentration of free chlorine should be increased to greater than 0.5 mg/litre throughout the system as a minimum immediate response. It is most important that decisions are taken in consultation with public health authorities and, where appropriate, civil authorities (see also section 8.6).

7.6.1 Boil water and water avoidance advisories

Water suppliers in conjunction with public health authorities should develop protocols for boil water orders and water avoidance advisories. Protocols should be prepared prior to the occurrence of incidents and incorporated within management plans. Decisions to issue advisories are often made within a short period of time, and developing responses during an event can complicate decision-making, compromise communication and undermine public confidence.

In addition to the information discussed in section 4.4.3, the protocols should deal with:

Table 7.8 International Organization for Standardization (ISO) standards for detection and enumeration of faecal indicator bacteria in water ISO standard Title (water quality)

6461-1:1986 Detection and enumeration of the spores of sulfite-reducing anaerobes (clostridia)
— Part 1: Method by enrichment in a liquid medium 6461-2:1986 Detection and enumeration of the spores of sulfite-reducing anaerobes (clostridia)

— Part 2: Method by membrane filtration 7704:1985 Evaluation of membrane filters used for microbiological analyses

7899-1:1984 Detection and enumeration of faecal streptococci – Part 1: Method by enrichment in a liquid medium

7899-2:1984 Detection and enumeration of faecal streptococci – Part 2: Method by membrane filtration

9308-1:1990 Detection and enumeration of coliform organisms, thermotolerant coliform organisms and presumptive *Escherichia coli* – Part 1:

Membrane filtration method 9308-2:1990 Detection and enumeration of coliform organisms, thermotolerant coliform organisms and presumptive

Escherichia coli – Part 2: Multiple tube (most probable number) method

The proposed ESMP plan above reveals that reducing the impact of gold mining does not only concern the miners but the community at large.

In order to prevent underground and surface water pollution and protect the soil from toxic substances, the artisans have to report any intention of an environmental activity to be carried out in their locality to the village chief before, during and after it is done. Artisans, the village chief and the delegation for the environment have to visit the site before, during and after mining activities in the site so as to minimize landscape degradation and destruction of flora and fauna orchestrated by this activity. Health issues such as the proliferation of STDs should equally be looked upon by the NGO community. Unemployment after the mine closure remains an inevitable problem if the artisans and village chief do not encourage miners to develop parallel activities that will help them later. In order to avoid low rates of child education, the NGO, village chief and local community have to formally band children below 18 to work in the mining sites and equally sensitize parents on their duty to take care of the education of their children.

The ESMP proposed above has to be monitored so as to obtain the objectives needed. A monitoring plan is proposed in table 13 below.

Table 14: Monitoring plan

Receivin g environ ment	Action	Objectiv e	executin g actors	Duratio n	Monitori ng indicatio ns	Executio n plan	Material	Cost
Water	Constr uction of a water drainag e system Constr	Canalizi ng of mining waste water Avoid pollution	Local collectiv e Artisans	Throug hout the exploita tion	Water flow monitori ng Inspectio n of treatment plans	Daily verificati on of water drainage Daily verificati on of	Drainage pipes Construc tion Of pits	820000 00

	uction of pits for the storage and treatme nt of effluen t					effluent treatment		
Soil	Agricul tural upgradi ng	Fertilize soil	Local collectiv e	After mine closure	Control fertility indicator s	Upgradin g after exploitati on	Use of organic fertilizer Use of waste plastic bags	1,800,0 00
Fauna and flora	Affores tation Protect ion of species Filling of pits	Vegetati on reconstru ction Biodiver sity preservat ion Avoid	Local collectiv e Local collectiv e Locale collectiv	Progres sive Throug hout exploita tion On	Plant care and observati on Observat ion Observat ion	Monitori ng of plants Fauna and flora protectio n plan Field Inspectio n by the urban	Excavato r	5.000.0 00

		pits	e	open pits		communi ty		
Health and security	Trainin g of the artisans on hygien e	Reduces diseases due to poor hygiene	The presence of health centres in the locality	Before and during exploita tion	Consulta tion rate	Monthly rapport on consultat ion rate	Sensitisa tion campaig n	2.500.0 00
	Put in place arm forces in the site	Ensure the security of the gold miners and the local populatio n					Distribut ion of contrace ptive Construc tion of toilets close to the mining site Putting in place of a security post	
Econom y	Compe nsation of terrain	Compens ate for farm	The state	Before exploita tion	Rate of complain ts	Compens ation plan before		3.000.0 00

	properties	lands				exploitation		
Educational and livelihood	Official prohibition of mine workers less than 18 years Sensitisation of women on their role in the family	set up communal laws which encourages child education and women to play their family role.	Community village chief NGO	Before and during exploitation	Number of children in the locality Number of women actively playing their family role	Verification of the number of families living together in this locality	Sensitisation campaigns	2.000.000

Source : investigations, november 2020

The table 13 above reveals that in order to carry out gold mining activity with limited impacts on the components of the ecosystem, certain actions have to be done which will equally need finances. As such, it will cost about 82 000 000 frs to construct a water drainage system and pits for the storage and treatment of effluents and strict follow up so as to reduce its impact on water, 1 800 000 to purchase fertilizers to upgrade the soils after exploitation so it could be used again for agriculture as they formerly did. In order to purchase an excavator to fill the pits created and reconstitute the vegetation, about 5 000 000 frs will be needed. Concerning the training of the artisans on hygiene and establishing a station for the forces of order to reduce diseases and ensure security, about 2500000 will be needed. About 3 000 000 will be required to serve as compensation for the farmlands destroyed during this activity and

about 2000000 for the prohibition of children and women to carry out this activity at the detriment of their studies and homes. Thus the implementation of this monitoring plan will cost around 96, 2 million.

It should be noted that these amounts are just mere estimations obtained from the SONAMINE office found in that locality.

IV.2. Recommendations

IV.2.1. To the Government

Our recommendations to the state relate to:

- Draft a law specific to artisanal and semi-mechanized gold mining;
- In response to all these environmental problems that Cameroon is facing today which are the results of mining operations, we propose the following priority actions:
- Control of deforestation during mining;
- The decontamination of watercourses and the conservation of aquatic biotopes;
- Pollution control relating to the use of mercury, arsenic and cyanide in all gold mining sites;
- Control and reduction of effluents during extraction; The rehabilitation of sites and wells; the establishment of regulations relating to the exploitation of alluvium.
- Ensure that semi-mechanized exploitation is only carried out by nationals as stipulated in the mining code of December 14, 2016 [17];

Impose obligations on the various administrative actors in order to implement summary ESIA's in accordance with Order 0070 / MINEP of 22 April 2005 fixing the different categories of operation whose completion is subject to an environmental and social impact study (Art. 3, IV, E) [28].

- Must use the share in terms of finance going to the municipality of the locality of Djouzami (Meiganga) to provide the village with water points and current and a secondary school to facilitate access to education.
- Must ensure that each ministry involved in mining projects formally fulfills its mission

IV.2.2. To SONAMINE

- Reinforce the capacity of the artisans by educating them on efficient mining technics.
- Prohibit children from working in the mining sites.
- Establish a security control system in the mining sites.
- Furnish gold miners with handy equipment to facilitate their work.

IV.2.3. To the civil society organizations

Reinforce sensitization on:

- Regrouping of artisans in to association and corporative were they can exchange ideas with other actors in the mining domain. These associations can provide health programs were all the people involved in artisanal mining can mutually enjoy health benefits.
- The importance of educating their children instead of letting them work in the mining sites.
- The importance of a woman's role in the family.

This chapter summarizes the discusses the results of our investigations presented in the previous chapter, proposing measures of compensation, an ESMP together with a monitoring plan to make sure this plan is being carried out. It ended with some recommendations to the government, SONAMINE service and civil society organizations.

GENERAL CONCLUSION

The main objective of this work was to contribute to the evaluation of the environmental and social impact of artisanal and semi-mechanized mining in the locality of Djouzami and also propose an environmental and social management plan (ESMP) in order to ensure the wellbeing of the population and safeguard their resources. Several researches and field investigations were carried out. A field work was carried out; the water samples (E1, E2 and E3) were characterized microbiologically to evaluate the water quality contamination. The results of the microbiological analysis showed the abundant presence of Fecal coliform (FC), Fecal Streptococci (FS) and *Escherichia coli* (E. coli). All of the above results provide ample evidence of the role of mining in the deterioration of water quality making it a primary source of waterborne diseases in this locality. Environmental tools specifically the Leopold matrix, Ishikawa diagram, and the Martin Fectaeu grid were used to identify assess and evaluate the impacts mining activity in this locality. A correlation matrix approach was used to determine if the of impacts were of anthropic or natural source. The identification and evaluation of Impacts reveals that the semi mechanized artisanal mining in Djouzami though very economically profitable has very significant environmental consequences such as land degradation, deforestation, soil pollution, water pollution and landscape modification. It was also noticed that a majority of the health issues in this locality are related directly or indirectly to the mining activity. Lastly an ESMP was proposed to prevent, mitigate and compensate the impact.

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ANNEXES

Annex 1: Survey questionnaire

Section 1 : Actor identification

Last name and first names
:

Gender of the person questioned : M ou F

Nationality :

Ethnic Groupe :

Date and place of birth :

At :

How many children do you have on the site :
.....

Have you gone to school? YES NO

If yes what grade level? Primary Secondary Superior

What is your principal activity on the minning site:
.....

Do you have a secondary activity ? YES NO If yes, quote them :
.....

How long have you been working on the site ?
.....

Appartenez-vous à un Groupe d'Initiative Commune (GIC) : OUI NON

Si oui,
lequel ?
...

Que faisiez-vous avant de commencer à travailler sur le site minier ?
.....

Section 2 : Environmental aspects of artisanal gold minning

Do you think that the artisanal gold minning has an impact on the environment (forest, soil, water)?

Not at all:

.....

A little bit :

.....

Moderately :

.....

A lot :

.....

Very much :

.....

What do you think are the most important environmental issues of artisanal mining ?

	Not at all	A little bit	Moderately	A lot	Verry much
Deforestation					
Soil disintergration					
Water pollution					
Decrease in fish					
Decrese in bush meat					

Other, precise:

.....

Have you tried to reduce the evironmental impacts? YES NO

If yes, which disposition have you taken?

Limite deforestation:

Water course restoration :

.....

Backfill the holes :

.....

Practice reforestation and afforestation to restaure the soil :

.....

Other, precise:

.....

If not, why?

Abandonment of the site after operation exploitation

.....

It is not possible to reduce the impacts

.....

I don't know how to solve the problem..... Other, precise:

.....

Is there any organisation or cooperation between miners to protect the environment and rehabilitates sites after exploitation and closeur? YES NO If yes, which one's ?

..... Other, precise :

.....

Section 3 : socio-economic aspects of the artisanal gold mining

Has the operation of the mine destroyed activities that existed before the mine ? YES

NO If yes, which one's ?

.....

Has the operation of the mine destroyed any activities on the site ? YES NO If yes, which one's ?

Has the mining activities prevented the creation of new income generating activities? YES

NO If yes, which one's ?

.....

Who is the principal financier of the site?

Myself a collector a resourceful

Other, precise :

.....

Are you working on under written verbal or written contract with a collector or a resourceful ?

written verbally no contract

Do you want to stay on the mine site after it has closed ? YES NO

Why?

.....

What do you think are the most important resources of the income?

	Not at all	A little bit	Moderately	A lot	Very much
Agriculture					
Trade					
knitting					
Mining Activity					
Fishing					
breeding					
Hairdressing					
sewing					

Do you think that women have a role to play in artisanal gold mining ? YES NO

If yes, why?

.....

...

Do you think that women have a role to play alongside artisanal gold mining ?

YES NO

If yes, why?

.....

...

Do you think women have a role in rehabilitating artisanal gold mining sites? YES

NO

If yes, why?

.....

...

Do you think there are rule that minors must follow to protect the environment ?

YES NO

Are you in favor of the agricultural rehabilitation of the sites after closure ? YES

NO

If not,specify another alternative :

.....

Do you have any family members sick from the gold mining business?YES NO

If yes, how many personnes ?

.....

Have you ever lost a family member because of gold mining operation? YES NO

If yes, how many personnes ?.....

Annex 2: Questionnaire for the attending doctor

Lastname and firstname :

.....

Speciality :

.....

Departement :

.....

What are the diseases commonly encountered in the locality?.....

.....

Are any of these diseases related to gold minning activity ? YES NO If so, why?

.....

Do people suffer from diseases linked to nwater quality ? YES NO If so, why?

.....

Do you carry out the biological diagnosis of the bacteria in your health structure? YES
NON

What tests do you use in the laboratory for the diagnosis of the diseases?

.....

.....

.....

.....

In the event of a positive result, what type of treatment do you prescibe?

.....

.....

.....

Do you have any facilities related to gold mining activities? YES NO

If so, how often?.....

Do you feel a positive impact of the presence of minning sites on your health services ?YES

NO If yes,

which?.....

...

Annex 3: Aerial view of abandoned mining sites



Source; Mefomdjo January 2021