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# Study of the Working Conditions of Semi-Industrial and Traditional Gold Miners in the Central Region of Togo and Their Impact on the Environment

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## Abstract

This work aims to contribute to the knowledge of gold panning and its impacts in forest ecosystems in the central region of Togo. The methodology is based on the inventory of the types and characteristics of farms, as well as an evaluation of the environmental impacts observed and spectrophotometer analyses. Remote sensing was used to assess forest degradation. Occupying 18 sites out of the 20 identified, artisanal exploitation remains dominant (i.e. 90%) compared to semi-industrial exploitation. Artisanal exploitation is practiced by Togolese and certain foreigners (Burkinabés, Beninese, Ghanaians and nationals of West African countries) organized in light teams while semi-industrial exploitation is practiced by Chinese companies. The negative impacts noted on the environment of the sector are: degradation of the plant cover, disturbance of the wildlife environment excavations, stagnation of water and asphyxiation of plants, landslides, modification of the landscape, piles of gravel and overburden, increase in the turbidity of the water, disruption of the water flow regime, risk of accident. The impacts identified for semi-industrial and artisanal gold panning are of remarkable importance.

## Keywords

Gold Panning, Turbidity, Ecosystem, Pollution, Traditional

## 1. Introduction

Gold panning is an ancestral practice still practiced today, which consists of concentrating and extracting gold using manual and semi-mechanized methods and processes (Organisation mondiale de la Santé, 2017; Navch et al., 2006). The management of the environment and natural resources is one of the major concerns of sustainable development today (Bamba et al., 2013). Forest ecosystems are constantly under pressure from anthropogenic activities such as gold panning (Slama & Cordier, 2013), whose consequences are catastrophic for both the physical environment and biodiversity (Watha-Ndoudy et al., 2022). This activity contributes to increasing the income of local populations despite the difficult conditions in which it operates (Bohbot, 2017; Herbert et al., 2009). However, the exploitation of these resources often has no significant economic spin-offs for the local population, and is also a source of environmental degradation (Kouakou et al., 2022; Kristensen, Thomsen, & Mikkelsen, 2014; Amadou, n.d.), endangering certain vital heritages (soil, water, vegetation, etc.) (*L'impact de l'exploitation artisanale de l'or (orpaillage) sur la santé et l'environnement: Médiaterre*, n.d.; Dipakama et al., 2024). Land degradation, in the form of clearing large areas of forest and vegetation to extract ore, has short- and long-term environmental and health impacts (CRDI—Centre de recherches pour le développement international, n.d.). This is why, after the exploitation of certain resources, many sites remain potentially contaminated by various harmful chemical substances (Goix 2012; Abri & L'environnement, 2023), particularly trace metals (TMEs) (Wang et al., 2024; Seidl et al., 2016). Hundreds of sources of groundwater (boreholes, wells) and surface water (rivers) were polluted, resulting in the death of aquatic animals and marine flora (Seidl et al., 2016; Maiga et al., 2022). The occupation of riverbanks for mining purposes destabilizes banks, and massive sediment inputs can locally disrupt river equilibrium and increase water turbidity, compromising productivity and biological diversity (Bamba et al., 2013; Alexandre et al., 2019; Ouedraogo et al., 2024). Deforestation, worsening of erosion and landslide phenomena, soil subsidence, pollution from chemical discharges are also the negative impacts of gold panning (Maiga et al., 2022; Organisation mondiale de la Santé, 2017). Habitat loss and landslides occurred, along with the loss of biological diversity, destruction of protected forests and protected trees species, all for the benefit of gold panning (Ohou-Yao et al., 2014). The law on mining governance regulates the use of chemicals in gold panning (Ohou-Yao et al., 2014). This study is part of a process to diagnose the quality of surface water in gold panning environments, and the influence of gold panning activities on biodiversity, waterways and soils in the central region.

## 2. Materials and Methods

### 2.1. Geographical Location

As its name suggests, the Central region is the portion of Togolese territory located in the center of the country, separating the two regions of the south and the north. It is bordered to the north by the Kara region, to the south by the Plateaux region, to the west by Ghana and to the east by Benin. The Central region lies between parallels 8˚0 and 9˚15 north latitude on the one hand, and meridians 0˚15 and 1˚35 east longitude on the other as shown in Figure 1.

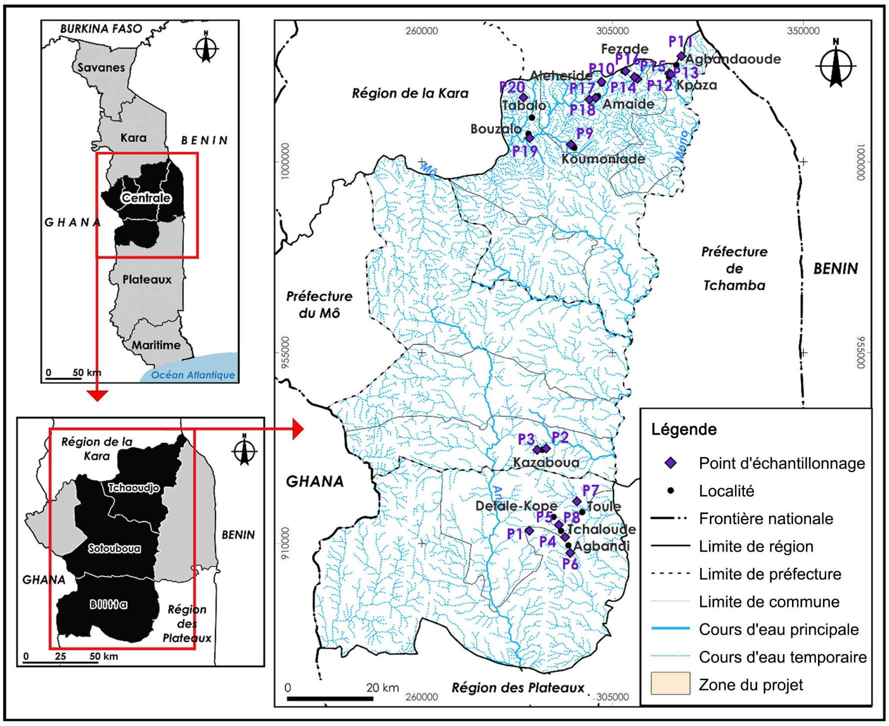


Figure 1. Map of study area. Source: Made by the authors with ARCGIS.

The central region comprises five prefectures: Tchaoudjo prefecture, Tchamba prefecture, Stouboua prefecture, Blitta prefecture and Mô prefecture. Gold-panning activities cover only three prefectures, in the following localities, according to the geographical distribution of sites (Figure 1): (Agbandi center, Diguina, Kaza kopé, Yamba cope) in the prefecture of Blitta; (Kaza, Kazaboua) in the prefecture of Sotouboua; (Bouzalou, Tabalo, Aleheleridè, Amaidè, Amaidenima, Amaoudè, Amaoude mô, Fézadè, Kemeni canton, Koumoniadè, Kolina, Agbandaoudè, Kpaza, Toboni, Tchambere) in the Tchaoudjo prefecture.

Exploitation sites are characterized by the wild and very disorganized emergence of pits and quarries like dung beetle galleries (Ribier et al., 2021). On these sites, there are heaps of sterile rock or sand rejected during the digging of shafts in search of rock.

## 2.2. Central Region Demographics

According to the general population and housing census of October 2022, the central region ranks last with an estimated population of 795,529 inhabitants, including 397,336 men and 398,193 women. Of these figures, the prefecture of Tchaoudjo is the most populous, with an estimated population of 240,360, including 119,126 men and 121,234 women, followed by the prefecture of Tchamba with 200,585 inhabitants, including 100,980 men and 99,605 women, Blitta prefecture 163,272 inhabitants, 81,602 men and 81,670 women, Sotouboua prefecture

138,864 inhabitants, 69,140 men and 69,724 women, and Mô prefecture 52,448 inhabitants, 26,488 men and 25,960 women.

## 2.3. Relief

The orography of the central region is marked by the presence of a mountain range that takes the area in a sling, but also by the existence of vast alluvial plains. Soil surveys reveal five types of soil in the region. These are lithosols, vertisols, tropical ferruginous soils, ferralitic soils and hydromorphic soils (marshy areas, riverbanks).

Vegetation is essentially linked to relief. The Mô and Mono plains are dominated by savannahs, while mountainous areas are covered by forests seriously degraded by human activity. Gallery forests are also found in the form of dense, linear woody stands along riverbanks.

The Central region is home to over 20% of the country's reserves and classified forests. These reserves constitute a vast natural territory, home to a variety of plant and animal species (buffalo, elephants, antelopes, primates and birds). The most important reserves are the Fazao-Malfakassa national park (1920 $km^2$), the Abdoulaye forest (300 $km^2$), the Aou-Mono forest (60 $km^2$), the Malfakassa-Tabalo forest (40 $km^2$) and the Mount Balam Forest (40 $km^2$).

## 2.4. Climate

The region is marked by two distinct seasons, one rainy and the other dry, of almost equal duration. The rains last from April to October, with a peak between July and September. The dry season extends from November to March. Annual rainfall varies between 1100 mm and 1500 mm for a number of days between 100 and 120. Rainfall totals range from 1200 to 1500 mm per year.

Sunshine duration fluctuates around 2500 hours per year, resulting in average evaporation of 1600 mm of water. Evaporation varies considerably from one year to the next. It sometimes reaches 1600 mm per year, which is higher than annual rainfall in the region.

## 2.5. Vegetation

Vegetation is essentially linked to the type of relief. The Mô and Mono plains are dominated by savannahs, while the mountainous areas are covered by forests seriously degraded by human activity. There are also gallery forests in the form of dense, linear woody stands on the banks of rivers.

## 2.6. Fauna

The Central region is home to over 20% of the country's reserves and classified forests. These reserves constitute a vast natural territory, home to a variety of plant and animal species (buffalo, elephants, antelopes, primates and birds). The most important reserves are the Fazao-Malfakassa national park (1920 $km^2$), the Abdoulaye forest (300 $km^2$), the Aou-Mono forest (60 $km^2$), the Malfakassa-

Tabalo forest (40 $km^2$) and the Mount Balam forest (40 $km^2$). The survey revealed that the total number of people involved in gold panning in the Central region is estimated at 4888. The age and gender breakdown of the gold panning population is presented below.

### 2.7. Methodology

The methodology used was based on the following activities: 1) surveys, in the form of focus group interviews with a sample of 50 gold miners surveyed per site at 20 sites, which makes a survey population estimated at 1000 gold miners across all sites out of a population of 2488 according to the survey figures; 2) presentation of gold panning activity; 3) turbidity measurements using the SpectroDirect/PC spectro II.

## 3. Results

### 3.1. Types of Gold Mining in the Study Area

Of the 20 sites surveyed, traditional gold panning is practised at 19 sites, i.e. a rate of 95% in the study area, while semi-mechanized gold panning, which is in the minority (5%), is only practised at 2 sites as shown in Figure 2.

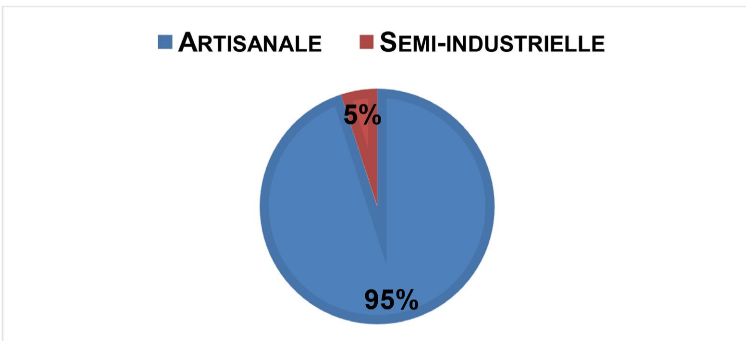


Figure 2. Proportions of farm types in the central region.

### 3.2. Distribution and Organization of Gold Miners at Mining Sites

Figure 3 and Figure 4 shows the age and gender distribution of gold miners in the region.

#### 3.2.1. Age Distribution

The results of the inventory show a workforce of 4888, broken down by age group. We note a strong dominance of adults (18 to 60 years) 3910, or 79.9% followed by children (<18 years) 831, or 17% and finally the elderly (> 60 years) 147, or 3.01%. The youth workforce in Tchaoudjo prefecture is larger than in other prefectures. For people in the 18 - 60 age bracket, Tchaoudjo prefecture comes first with 2347 individuals, followed by Blitta prefecture with 1073 and 490 in Sotouboua prefecture. Tchaoudjo prefecture also has more elderly people than the other prefectures as shown in Figure 3.

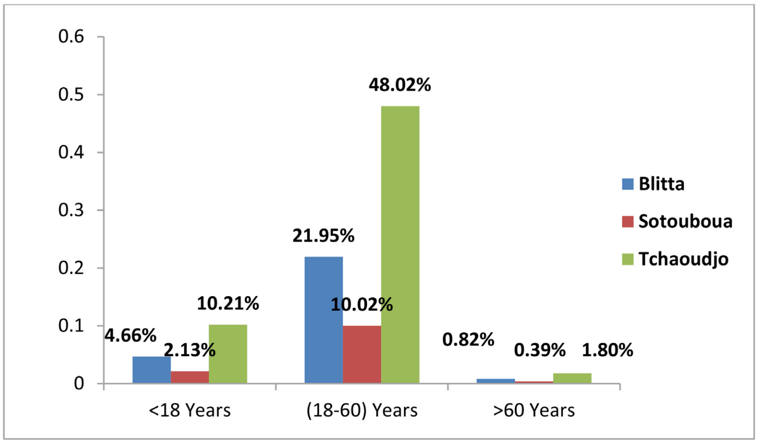


Figure 3. Age distribution of the population.

#### 3.2.2. Gender Distribution by Region

In all the study areas where gold panning is practiced, the population is made up of 2647 males (54.15%) and 2241 females (45.15%).

The Tchaoudjo prefecture is home to more male (1563) and female (1371) gold miners. Blitta prefecture has 585 female and 756 male gold miners, while Sotouboua prefecture has 328 male and 285 female gold miners. The regional and prefectural gender distribution in the Central Region's gold-mining zones as shown in Figure 4.

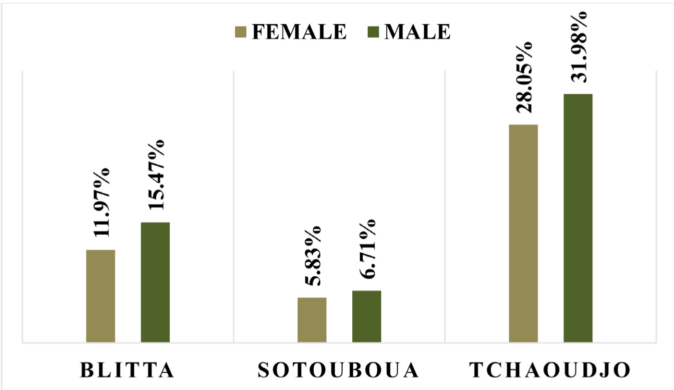


Figure 4. Gender distribution of the population.

#### 3.2.3. Education Level of Gold Miners

On the goldpanning sites, the level of education also varies, with illiterate and literate people. The graph below shows the level of education on the sites studied as shown in Figure 5.

### 3.3. Gold Mining Techniques

Gold mining in the central region goes through 3 phases: The prospecting phase, the site preparation phase and the actual mining phase. Mining techniques and tools are rudimentary and manual at traditional and semi-mechanized sites as shown in Table 1.

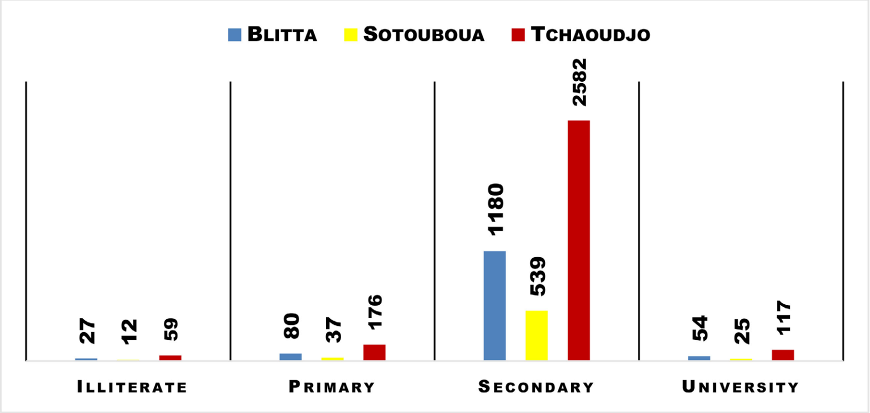


Figure 5. Goldpanners' level of education.

Table 1. Tools used in gold mining.

| Operating phases | Activities | Tools and resources used | |
|---|---|---|---|
| | | Artisanal mining | Mechanized operations |
| Prospecting | Clearing | Machetes, shovel, pickaxe | Hydraulic excavator |
| | Sounding | Mining rod, shovel, pickaxe | Hydraulic excavator |
| | Test | Paddle | Paddle |
| Site preparation | Clearing vegetation | Machetes, shovel artisanal, pickaxe | Hydraulic excavator |
| | Water supplies | Water pump, paddle, shovel artisanal | Water pump |
| | Extraction | Ladders, cans, plastic | Hydraulic excavator |
| Operation | Gravel storages | Shovel artisanal, cans, plastic | Hydraulic excavator |
| | Washing | Crates, settling | Laundries (small and Large motor pumps) |
| | Dewaters | Water pump, paddle | Laundries (small and large motor pumps) |
| Gold recovery | Gold recovery | Paddle, papers, sheets | Paddle, papers, sheets |

Gold panning activities in the central region generate negative impacts on the biophysical environment (vegetation, soil, landscape, fauna, water) and the human environment (safety). These include loss of vegetation cover, excavations, lake formation, rockfalls, water quality degradation due to increased turbidity, landscape modification, abandoned gravel heaps and dead land, drying up of watercourses, groundwater disturbance, disturbance of wildlife habitat, abandoned waste, accidents, noise pollution, over-alluviation of watercourses, plant asphyxiation.

Excavations, loss of vegetation cover, landscape modification, gravel heaps and abandoned overburden, disturbance of wildlife resources, and increased water turbidity are the most frequently observed effects at gold-mining sites; groundwater disturbance, noise pollution, lake formation, over-alluviation, abandoned waste and accidents are of medium frequency, while rockfall, drying up of watercourses and plant asphyxia are of low frequency, as they are only observed at a few sites (Watha-Ndoudy et al., 2022; Mpassi Tsiba et al., 2023) as shown in **Figure 6**.

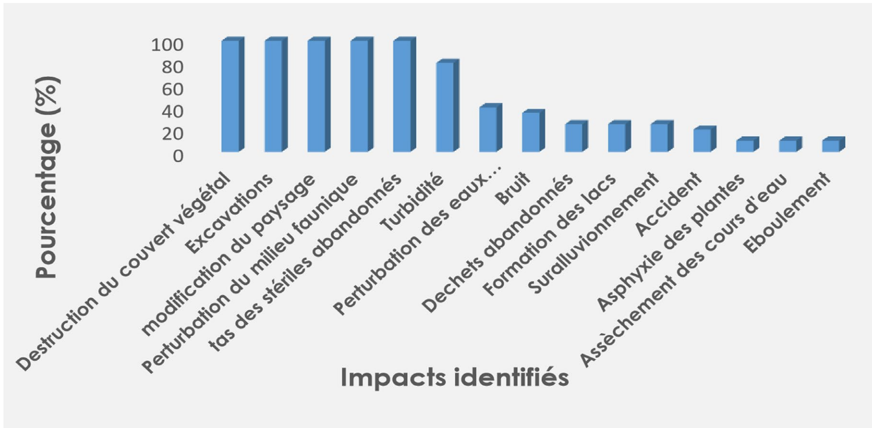


Figure 6. Proportions of impacts identified at gold mining sites.

## 3.4. Description of Identified Impacts on the Biophysical Environment

### 3.4.1. On Vegetation and Fauna

Semi-industrial or traditional gold panning activities in the Souanké area result in the loss and degradation of the area's forest resources, both flora and fauna. Clearing land during the search for mineralized zones, cutting wood to divert waterways and support pits, deforestation during site preparation and gold mining, and the discharge of ore washing water into the forest are all activities responsible for the loss of plant cover and the asphyxiation of plants. These activities also disrupt the wildlife environment, causing animals to move away from their habitats (Alexandre et al., 2019; Ndiaye, 2020; Slama & Cordier, 2013) as shown in **Photo 1** and **Photo 2**.

Photo 1. Loss of vegetation cover, December 2023, AGbandi 1.

Photo 2. Vegetation suffocation, December 2023, Alheridè river.

#### 3.4.2. On Soil and Landscape

The impacts of gold panning on the soil are identified at all stages of artisanal and semi-mechanized gold mining. During prospecting, pits are sunk, leaving holes here and there. During the mining phase, once the ore has been extracted, the presence of holes, excavations, the formation of lakes, landslides, gravel heaps, overburden and abandoned waste can be observed, all of which permanently degrade the soil as it is not reconstituted after mining.

The volume of excavations and spoil heaps on the sites depends on the type of operation and the frequency of activities. The volume is greatest at semi-mechanized sites, due to the ease of operation associated with the tools used (hydraulic shovels, mechanized washing machines, motor pumps, etc.).

These excavations are not backfilled at the end of site operations. They are subsequently filled with water, forming lakes. Rockfalls are infrequent in the area; they have only been identified at artisanal sites in Guinée and Ekokola (Kouamé & Lacina, 2022; Coppel, Gond, & Allo, 2008). All these impacts, identified both during and after gold mining, have à major impact on the landscape as shown in **Photos 3-6**.

Photo 3. Abandoned well serving as on-site water source, December 2023, Agbandi 2.

Photo 4. Waste disposal at extraction points, January 2024, Tchaloudè.

Photo 5. Disruption of the flow direction of the Alhéridè streams, January 2024, Kpaza river.

Photo 6. Destruction of yards and landslides in Alhéridè streams, December 2023, Kazaboua river border.

### 3.4.3. Water Resources

Water plays a vital role in gold panning, as it is involved in almost every stage of the mining process. Gold mining sites can be found all along watercourses, which is ample proof of its importance in the gold extraction process.

The operators reach the groundwater at a depth of a few meters, depending on the site, when digging. They then use motor-driven pumps or beaters to evacuate this water. This has a negative impact on groundwater quality and quantity. The same applies when ore washing is not carried out directly on the stream bed, with gold miners diverting the channels, draining the water from the streams using motor-driven pumps, or from one excavation to another when the stream is a long way from the washing point. The water is then stored in retention basins for use during ore washing. These operations disrupt the dynamics of the watercourses and lead to their drying up. This washing water is then returned to the watercourse after use. When mining takes place directly on the living bed of watercourses, the result is over-alluviation of the watercourses and an increase in water turbidity in the vicinity of the mining sites. Measurements of water turbidity in two characteristic rivers, the Rivière Agbandi, which drains a semi-industrial mining site, and the Rivière Kpaza for traditional mining, have shown that the Rivière Agbandi has a turbidity of 7 NTU upstream of the washing point and over 460 NTU from the ore washing point to 1000 m downstream of this point. The Kpaza River, on the other hand, has a turbidity of 10 NTU upstream of the washing point, rising to 260 NTU at the washing zone and gradually decreasing downstream. These results show that the water is more turbid downstream of the semi-industrial operation than in the traditional operation as shown in **Photo 7** and **Photo 8**.

**Photo 7.** Turbidity of water in the kpaza stream, January 2025, Alheridè river.

**Photo 8.** Bank escavation on the Alhéridè River, December 2024, Alheridè river area.

#### 3.4.4. On the Human Environment

The impact of gold panning on the safety of miners depends on their working conditions and the techniques used. Gold miners work in precarious conditions, with no safety measures in place. The presence of machinery, pipes, waste and excavations on the sites has been noted. Mining sites are abandoned without being rehabilitated, with metal and plastic wrecks. These changes, coupled with the lack of personal protective equipment, increase the risk of accidents for gold miners, exposing them to injury and even death as shown in **Photos 9-12**.

#### 3.4.5. Impact Characterization and Assessment

In the study area, the environmental and social impacts generated by gold panning activities have a negative value, i.e. there is a deterioration in the biophysical and human environment.

**Photo 9.** Alluvial mining in the Toulé River, July 2024.

**Photo 10.** Ore extraction on conveyor belt at Agbandi center, Agbandi center, July 2024.

Photo 11. Use of motor-driven pumps at Agbandi center, July 2024.

Photo 12. Alluvial extraction at Kpaza, September 2021.

These impacts are all identified in the immediate environment of the gold panning sites, with the exception of turbidity, which extends more than 1000 m downstream of the semi-mechanized sites.

#### 3.4.6. Impact of Gold Panning on Turbidity: Increased Turbidity

As artisanal mining is carried out along riverbanks, the water is continuously turbid and oxygen levels are reduced, causing the death of animal and plant species, which are often uprooted as shown in Figure 7.

Turbidity acts as a stress factor for aquatic ecosystems by limiting the production of $O_2$ (via photosynthesis) and increasing its consumption (through respiration and decomposition). Turbidity, caused by suspended particles (clay, silt, phytoplankton, organic matter), limits the penetration of light into the water (Alexandre et al., 2019). Consequence: Aquatic plants and phytoplankton (primary producers) produce less $O_2$ through photosynthesis, because it depends on light. Suspended particles can form a surface layer that limits the exchange of $O_2$ between the atmosphere and the water. Very turbid waters often have a “choked” surface, reducing natural reoxygenation. Rainfall/runoff: Increases turbidity by adding sediment, while leaching nutrients (accelerating eutrophication) (Meyeno-Ilougou, 2023). Human activities: Dredging, industrial discharges, or intensive agriculture exacerbate turbidity and disrupt the $O_2$ balance.

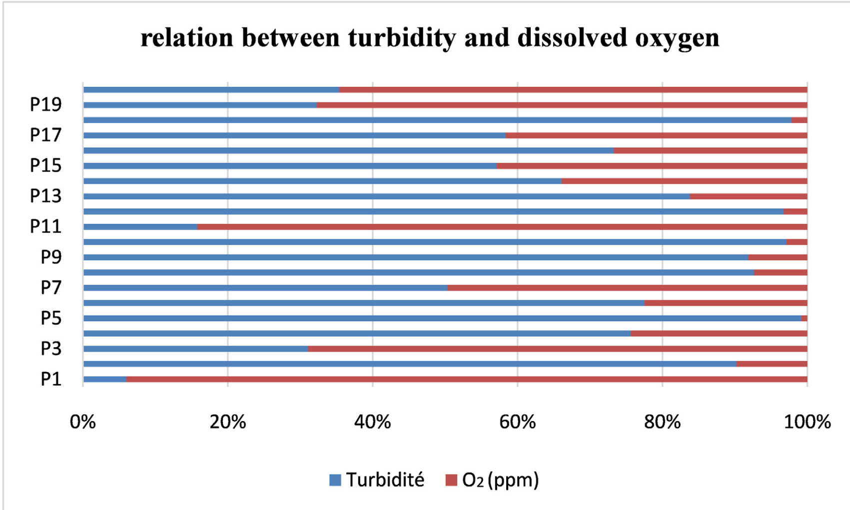


**Figure 7.** Relationship between turbidity and dissolved oxygen.

## 4. Discussion

The study presents the immediate visual impacts and hardly addresses the long-term aspect due to the choice of data available after surveys and water sampling on the sites. The analyses of the physicochemical parameters do not present an in-depth analysis of the long-term impacts. However, it should be noted that this part will be addressed and discussed after analysis of trace metal elements in water and soil which are sources of long-term pollution according to several studies that have been carried out in this direction (CRDI—Centre de recherches pour le développement international, n.d.).

Gold panning is practised traditionally at 95% of sites in the central region, using rudimentary techniques and tools, with the exception of motor-driven pumps which are sometimes used for drainage. This situation is due to the limited resources of the area's gold miners. There are barely any artisanal miners using mechanized tools in the area. This result corroborates the observations made by Seydou, 2001 in Mali, where extraction and processing methods are rudimentary, and mechanized workstations very limited in number.

Gold miners often organize themselves into teams of 5 people on the sites, given the volume and even the arduousness of the work. They are organized into cooperatives in this sector, as has been observed in other localities where gold panning activities are developing in Côte d'Ivoire, Congo and Burkina (Bohbot, 2017; Kouakou et al., 2022; Ohou-Yao et al., 2014; Mpassi Tsiba et al., 2023). This observation is contrary to that made in Cameroon, where gold miners work in co-operatives and are associated with support structures that provide them with the logistical (material and technical) support they need to carry out their activity (Ngounou Ngatcha et al., 2001). The negative environmental and social impacts generated by gold panning (artisanal and semi-mechanized) in the area are numerous, affecting vegetation and wildlife, soil, landscape, water resources and human safety.

As far as vegetation is concerned, we note the loss of plant cover, the asphyxiation of trees and the disruption of wildlife habitat. The installation of gold miners at mining sites involves clearing, uprooting trees and even cutting down timber. These activities are responsible for the loss of vegetation cover. An exception in the Congo is the asphyxiation of identified plants, which in this case is due to a lack of root oxygenation caused by poor drainage. This phenomenon can be observed in temperate zones, where a very wet winter keeps the land flooded for a long period, preventing respiration and literally suffocating the trees. As far as wildlife is concerned, there is a disturbance that translates into the removal of wildlife species and the destruction of their habitat. This is caused by the destruction of the vegetation cover, coupled with sinking activities, machine traffic, the atmosphere and noise pollution on the mining sites. This observation corroborates that of Digbo et al., 2021. The landscape is altered, with striking glimpses as far as the eye can see of excavations, lake formation, rockfalls, abandoned waste, gravel heaps and dead abandoned land. With regard to water resources, there has been an increase in the turbidity of gold-bearing surface waters, the over-alluviation and drying-up of watercourses, and the disruption of groundwater, linked to well-digging activities that expose the water tables in the study area. Soma et al., 2021, noted the presence of suspended solids and increased water turbidity in streams where gold-bearing sand is washed in Burkina Faso, Djangbedja et al., 2018 assert that gold panning leads to silting and silting up of river beds. These results are also in line with those found by Affessi et al., 2016, who also confirm the modification of groundwater flows by gold panning activities (Watha-Ndoudy et al., 2022).

Impacts on the human environment are marked by accidents and noise pollution. Working conditions are precarious (Augé et al., 2020), leading to accidents that often result in injuries, snake bites and occasional human deaths in underground mining operations following rockfalls. These accidents are linked to the lack of safety measures, the presence of machinery, metal and plastic wrecks, abandoned and water-filled excavations on the sites.

To these can be added the immediate consequences of soil erosion and chemical water pollution, although these have not been assessed. These impacts are those already observed in other countries such as Guyana, Mali, Senegal and Côte d'Ivoire, by (Coppel, Gond, & Allo, 2008; Pignoux et al., 2019; Abdourhamane Touré et al., 2016; Simon, Jean-Claude, & Moussa, 2016).

On peut y ajouter les conséquences immédiates qui sont l'érosion des sols et la pollution chimique des eaux même si elles n'ont pas été évaluée. Ces impacts sont ceux déjà observés dans d'autres pays comme la Guyane, le Mali, le Sénégal et la

Cote d'Ivoire, par (Coppel, Gond, & Allo, 2008; Pignoux et al., 2019; Abdourhamane Touré et al., 2016; Watha-Ndoudy et al., 2022; Simon, Jean-Claude, & Moussa, 2016).

## 5. Conclusion and Recommendations

This study shows that gold panning at the plant is a source of numerous environmental and social impacts. The impacts observed are excavations, loss of plant cover, modification of the landscape, the presence of gravel heaps and dead abandoned land on the sites, disturbance of the wildlife environment, lake formation, increased turbidity, drying-up of watercourses, disturbance of groundwater, abandoned waste, accidents, noise, over-alluviation of watercourses, landslides, drying-up of watercourses and asphyxiation of plants. We're witnessing a real catastrophe as sites are degraded and abandoned without rehabilitation. There are no environmental management plans in place, nor is there any respect for the safety requirements of both semi-industrial and artisanal mining operations, which increases the risk of accidents.

Faced with this situation, measures need to be taken to better manage the environment in areas affected by gold panning activities. The following actions should be carried out:

✓ Raise awareness among gold miners of the scale of the environmental and social impacts associated with gold panning. This will involve promoting a good practice guide for the benefit of the various players involved in gold panning.

✓ Strengthen the institutional and regulatory framework of the artisanal mining sector. The first step is to establish a system for surveying and monitoring gold panning sites, then to organize artisans into producer groups for the purposes of capacity building, and to encourage all those involved in gold panning to restore degraded sites and systematically revegetate them.

✓ Set up a system for issuing artisanal mining authorizations or permits in the various potential deposit areas, with an obligation to comply with the good practice guide.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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