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Spatio-temporal dynamics and socio-economic analysis of gold mining in the municipality of Ouahigouya in northern Burkina Faso

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Abstract

The Yaadga region (northern Burkina Faso) is facing a proliferation of artisanal mining sites, with eighty-two sites recorded in 2018 across the region, including eight gold panning sites in the commune of Ouahigouya alone. This study aims to analyse the spatio-temporal dynamics of gold panning as well as its socio-economic and environmental impacts in the municipality of Ouahigouya. The methodology adopted is based on a diachronic analysis of Landsat satellite imagery (2005 and 2023) and Google Earth imagery (2002, 2006, 2013 and 2021), supplemented by field surveys. The results reveal a decline in vegetation cover and progressive soil degradation, reflecting significant negative impacts on the biophysical environment. From a socio-economic perspective, this activity generates substantial income for households, with average earnings ranging from 10,000 CFA francs to over one million CFA francs during the dry season; however, due to the risk of landslides, the activity is slowed down or even banned during the rainy season. Despite the vital economic role played by this activity, it gives rise to enormous social challenges (school dropout rates, prostitution, child labour, precarious working conditions) and also exerts pressure on the biophysical environment (soil degradation, loss of vegetation cover). Given the negative social and environmental impacts of gold panning, regulatory measures that take the local context into account are needed to ensure a greater contribution to development.

Keywords: Artisanal gold mining; spatio-temporal dynamics; Socio-economic impacts; Ouahigouya; Burkina Faso

1. Introduction

Burkina Faso is a country whose economy has long been based on agricultural production, with cotton as the country's main source of foreign exchange [1], [2]. The consequences of this crop are primarily an increase in agricultural land area, loss of soil fertility (as cotton is recognised as being highly soil-depleting) and the exacerbation of the effects of climate change due to changes in ecosystems and the degradation of forests and land. Since 2009, gold has emerged as the main driver of the Burkinabe economy. Dominated by both industrial and artisanal gold production, the mining sector now accounts for nearly 70% of export earnings, thus constituting the primary pillar of the country's economy [3]. However, this dominant position in foreign trade contrasts with a low contribution to gross domestic product, which fluctuates between 15 and 20% depending on the year [4], [5]. This discrepancy highlights several challenges, including dependence on fluctuations in international prices and governance limitations [5]. In addition to industrial mining, artisanal gold mining has been the subject of sustained attention in the scientific literature, particularly due to its environmental impacts and socio-economic implications. In Burkina Faso, artisanal gold mining constitutes an essential

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source of income for many rural households, particularly in areas facing climate change, fluctuations or even falls in the prices of agricultural commodities, and a scarcity of formal jobs [6], [7], [8]. In the face of these challenges, artisanal gold mining acts as a socio-economic buffer [8], [9], [10]. This dual nature makes artisanal gold mining both a means of subsistence and a factor contributing to environmental and social vulnerability. The commune of Ouahigouya, located in the Yaadga region, fully illustrates this situation. It is among the areas with the highest density of artisanal gold mining sites, as evidenced by the National Survey on the Artisanal Gold Mining Sector, which identifies 110 active artisanal gold mining sites there [11]. The expansion of mining sites is taking place gradually at the expense of agricultural land, either through the deliberate abandonment of plots in favour of gold panning, or through soil degradation [12], [13], [14]. This is all the more worrying given the context of strong population growth of nearly 3.1% per year [11] and persistent food insecurity. According to available data, the food security coverage rate in this area is approximately 75%, compared with a surplus coverage rate of over 101% at the national level [15]. The aim of this study is to combine field surveys and remote sensing tools in order to understand the impact of gold panning within its overall context.

2. Material and methods

2.1. Presentation of the study area

The municipality of Ouahigouya is today the capital of the Yaadga region, one of the country's seventeen administrative regions introduced in August 2025. At the time of our field surveys (October 2023), this region did not yet exist; the commune was then part of the Nord region.

The municipality is crossed by National Road No. 02, the route linking Ouagadougou to Mopti in Mali (Figure 1). Ouahigouya is situated 181 km from Ouagadougou, 57 km from the Malian border and 222 km from the city of Mopti.

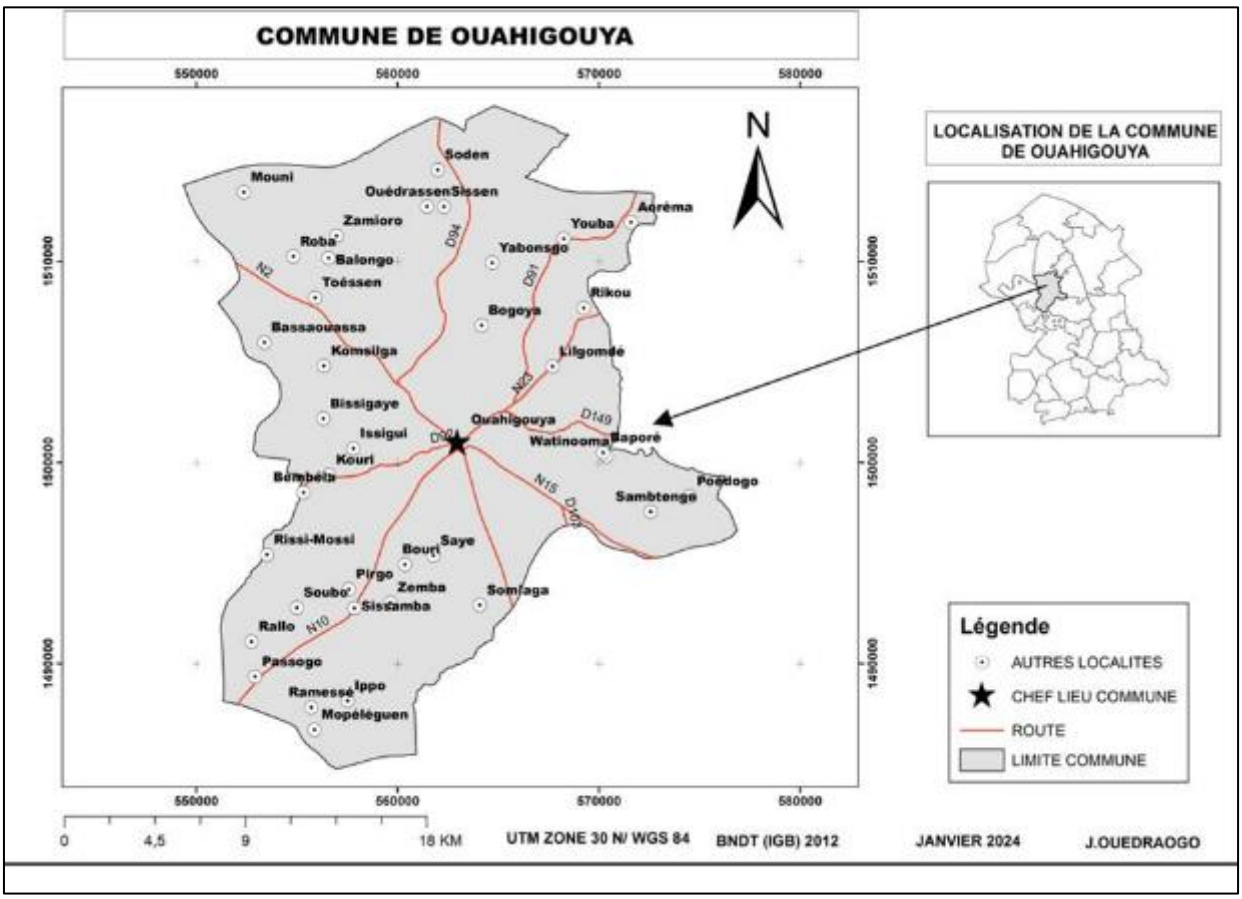


Figure 1 Map of the municipality of Ouahigouya

2.2. Mining context of the study area

According to the Communal Development Plan report (2017), the commune of Ouahigouya is rich in mineral resources. Gold, molybdenum, copper, and titanium- and vanadium-bearing magnetites are present there; kaolin, clays and

construction materials (laterites) are also found there. With regard to gold, the main resource studied, active gold panning sites can be found in Bogoya, Watinoma, Bembela, Youba, Yabonsgo, Sissamba and Soubo. Mining is strictly artisanal, and no industrial mining companies were established within the municipal area during the period of our study (October 2023).

2.3. Data collection tools

- Data were mainly collected using three technical and methodological tools:
- Semi-structured interview guides to support the survey;
- A Garmin 64 GPS to record the exact coordinates of the gold-panning sites, enabling the downloading and processing of satellite imagery;
- A digital camera to record visual documentation of these sites;

2.4. Geographical data collection

GPS coordinates were recorded at the gold panning sites; these coordinates were used to identify areas of interest for downloading Landsat images. To study the dynamics of vegetation cover, Landsat 7 (2005) and Landsat 8 (2023) images, downloaded in December 2023 from EarthExplorer (USGS), were used. These images were all taken in November for both years (2005 and 2023); this was done to avoid seasonal phenological variations that might affect the spectral state of the vegetation, thereby ensuring optimal comparability of the data between the two dates.

The characterisation of vegetation dynamics is based on the calculation of the Normalised Difference Vegetation Index (NDVI), whose mathematical expression is as follows

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

where: NIR (near-infrared); Red (red spectral band).

In addition, Google Earth Pro (2023) was used to obtain additional data on topography, land use and landscape changes.

2.5. Socio-economic data collection

To gain a deeper understanding of socio-economic aspects, a survey was conducted using semi-structured, individual interviews. A total of 108 people were interviewed. This method is best suited to similar contexts [15], [16]. The sample comprises key informants from decentralised environmental and mining services, local officials, representatives of the gold panners' union, site workers and households living in the surrounding area [17].

2.6. Data analysis and processing

Field data were recorded, entered and processed using Microsoft Excel (2023) for statistics and graphs, and QGIS 3.16 for mapping.

3. Results

3.1. Socio-economic analysis and demographic aspects of alluvial gold mining in Ouahigouya

Artisanal gold mining involves several social strata of the working population in the municipality of Ouahigouya. The survey data reveal a male predominance, with 88% men and 12% women, i.e. 95 men and 13 women respectively out of a total of 108 respondents (Table 1). It should also be noted that at the sites, women generally play a role in trade, re catering and beverages. Our data also show that the 18–35 age group is the most represented, with 60 people, or over 55% of the sample, whilst the 36–55 age group comprises 38 people, or over 35%, including 36 men and 2 women. The under-18 and over-56 age groups each account for 4.62%, or 5 individuals. According to the interviews conducted, the presence of minors at gold panning sites is due to the fact that they are with their family members. However, some minors are actively involved in gold panning (Figure 2).

Table 1 Breakdown of respondents by age group and gender

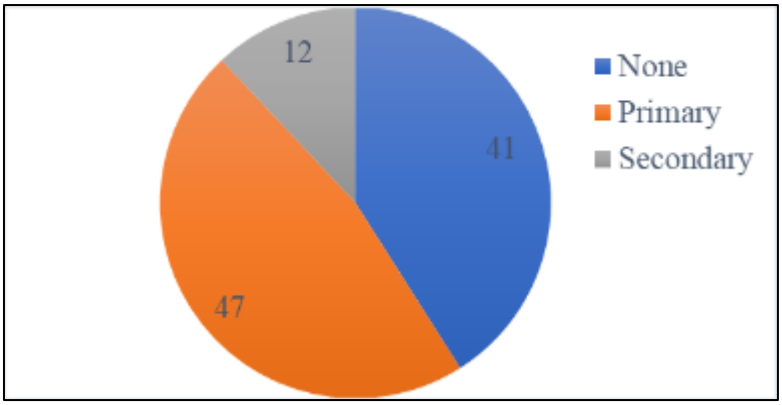
Age group	Men	Women	Total	Proportion (%)
Under 18	3	2	5	4.62
18–35	51	9	60	55.55
36–55	36	2	38	35.18
Over 56	5	0	5	4.62
Total	95	13	108	100%

Source: Field survey (October 2023)

Figure 2 Gold panning site in Ouahigouya; A: teenager; B: gravity washing of ore**.**

An analysis of the respondents' educational attainment highlights a key sociological characteristic of the population engaged in alluvial gold mining in the municipality of Ouahigouya, namely their low level of education. As shown in Figure 3, nearly half of the respondents (47 per cent) have only completed primary education, whilst 41 per cent report having received no formal education. Together, these two categories account for 88 per cent of the total sample, confirming that artisanal gold panning in this municipality is primarily a last-resort activity for people with little or no schooling, who often find themselves in a situation of socio-economic vulnerability.

Furthermore, only 12 per cent of those surveyed had completed secondary education, compared with a national rate of over 37 per cent [18].



Source: Field surveys 2023

Figure 3 Breakdown of respondents by level of education

3.1.1. Gold panning and the local economy in the municipality of Ouahigouya

The rise in the price of gold from less than €600 per ounce in 2005 to over €1,800 in 2023 (an increase of more than 216%) (Figure 4) is a key factor in the attractiveness of gold panning. [19] notes an increase in the price of gold of nearly 450% between 2000 and 2020. Thus, in a context where agricultural incomes remain low, further weakened by the growing effects of climate change, gold panning has become an essential economic activity for many rural households.

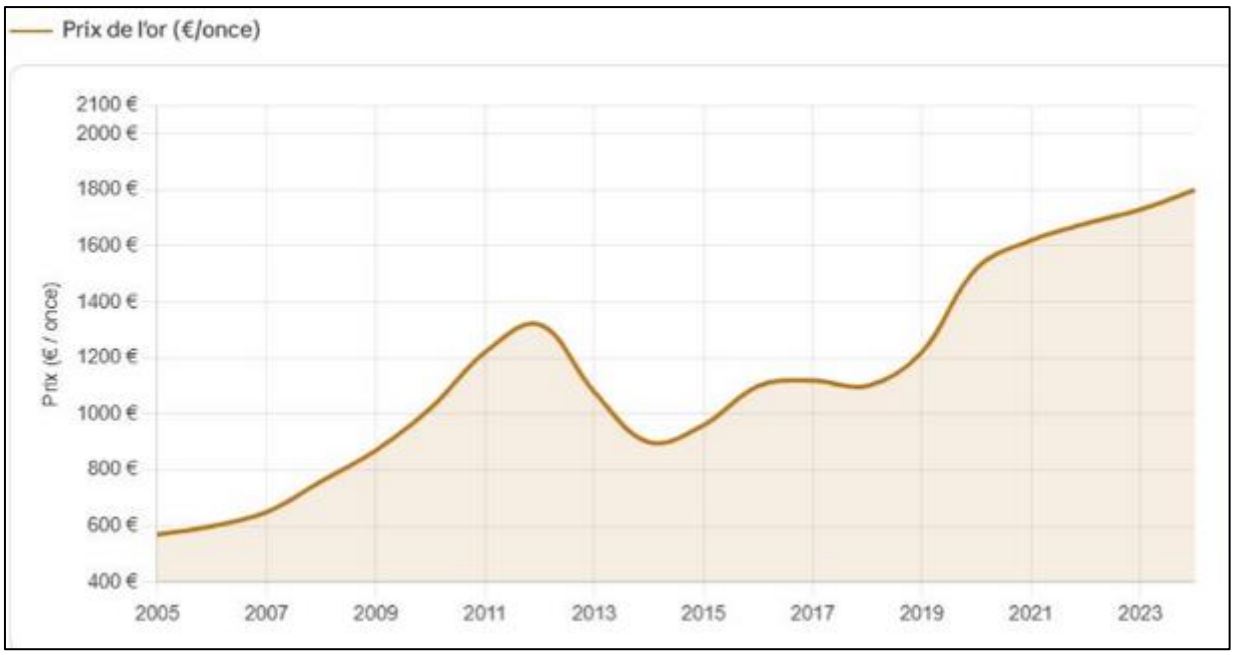


Figure 4 Gold price trends from 2005 to 2023 (Source: or.fr)

Whilst the price of gold determines the conditions conducive to the growth of gold panning at national and local levels, it is at the level of the stakeholders that the economic benefits are felt. The data collected during the research thus highlights two realities: on the one hand, the diversity of income generated across different categories of stakeholders, and on the other, an economic hierarchy organised around this activity

At the top of this hierarchy are the pit owners (generally, they are the ones who finance the exploration and mining of the sites); they can earn between 500,000 and over one million CFA-francs per season. The panners working at the sites are sometimes regarded as labourers: they are paid either by the task or according to a system of proportional sharing of the extracted ore. This group earns between 200,000 and 700,000 CFA francs per production season. Crushers, mostly women, earn between 10,000 and 150,000 CFA francs. Furthermore, service providers (catering, water sales, small-

scale trading) also participate in this informal economy by operating around the gold panning sites. Their incomes range from 100,000 to 500,000 CFA francs per season. This dynamic is explained by a well-known principle at mining sites: where gold flows, money flows. Prices for goods and services there are generally two to three times higher than those charged in the local area.

3.1.2. Changes in vegetation cover and land degradation at gold panning sites

The photographic plate (Figure 5) illustrates the main manifestations of biophysical degradation observed directly at the gold panning sites in the municipality of Ouahigouya during the field surveys in October 2023.

The diachronic study of vegetation cover, based on Landsat satellite imagery from 2005 and 2023, was conducted by calculating the Normalised Difference Vegetation Index (NDVI). The maps produced reveal a decline in vegetation cover across the entire study area (Figure 6).

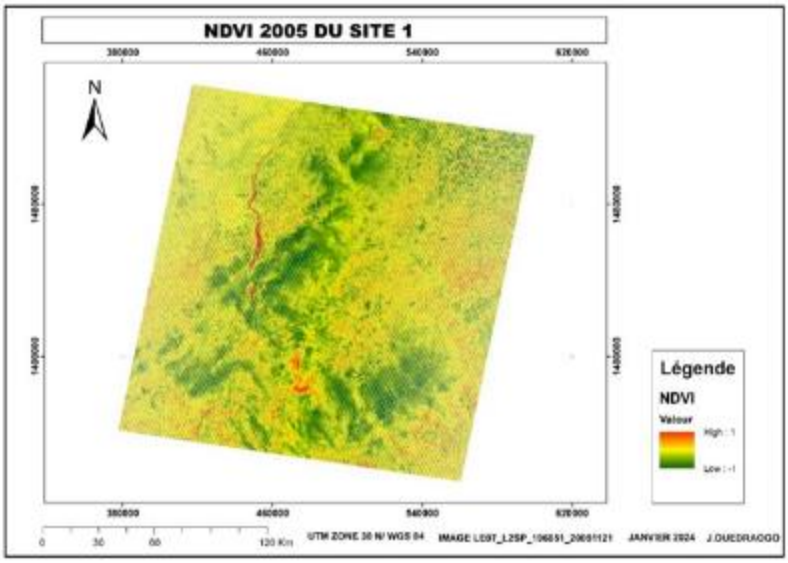
The impact of artisanal gold mining on the biophysical environment is an issue that cannot be separated from other anthropogenic pressures exerted on the natural environment. In the municipality of Ouahigouya, climate change, population growth and agricultural expansion constitute a pre-existing backdrop of degradation, to which gold panning is added as a further factor of degradation.

The results from the NDVI calculation are corroborated by Google Earth Pro imagery available for the years 2006, 2013 and 2021 (Figure 6). For both study sites, a reduction in vegetated areas is observed, with an increase in bare soil areas.

Figure 5 Biophysical features of gold panning sites in Ouahigouya A: Bare ground; B: Sinking of pits; C: Degraded pit; D: Crushing machine

This decline is visible in both Landsat satellite images and those from Google Earth Pro (Figure 7), reflecting a gradual alteration of the biophysical environment over the entire period studied.

However, this pattern of degradation is part of a broader environmental context, marked by the combined effects of climate change and population growth.


NDVI 2005 DU SITE 1
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Légende
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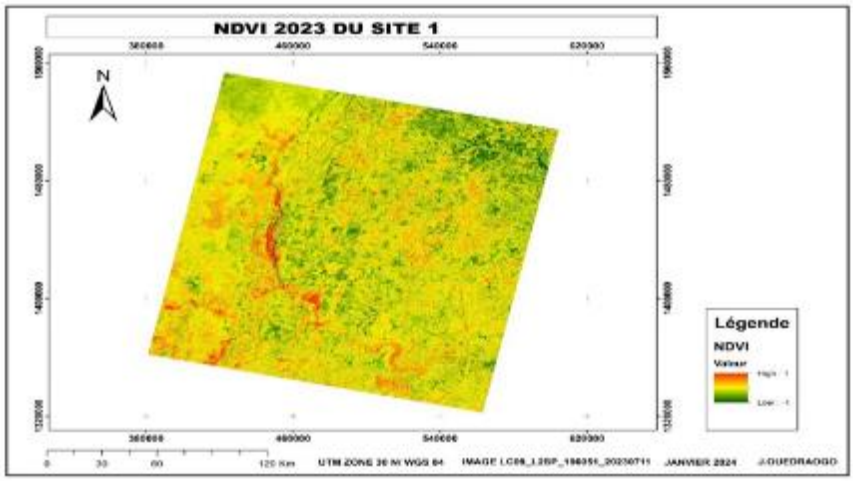
NDVI 2023 DU SITE 1
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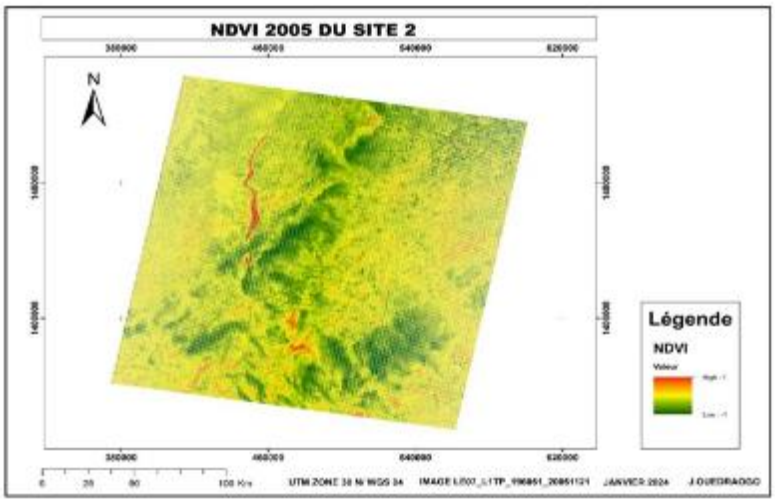
(A)


NDVI 2005 DU SITE 2
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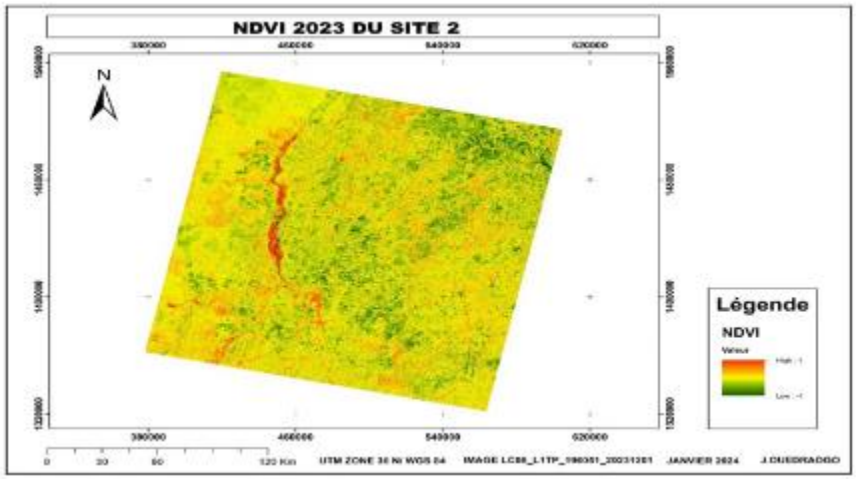

(B)

Figure 6 Changes in NDVI at gold panning sites in the municipality of Ouahigouya between 2005 and 2023

Google Earth Pro images (Site 1)

Google Earth Pro images (Site 2)

Figure 7 Google Earth Pro image showing changes in vegetation cover at the sites (2006, 2013, 2021)

4. Discussion

4.1. Expansion of gold panning: economic impacts and social transformations

The almost spectacular growth of small-scale gold mining has affected several communities in this sub-region of West Africa. Our findings demonstrate a tangible contribution to the local economy. [6] Sangaré (2016) notes that this remarkable expansion can be attributed to factors such as rising gold prices, technological advances in extraction

methods, and declining reserves in South Africa, which has long been the continent's leading gold producer. Thus, since 2024, Ghana has become Africa's leading gold producer with an estimated output of over 140 tonnes, followed by Mali with around 100 tonnes [13]. In Côte d'Ivoire, [12] Assoumane et *al*. (2025), [20] Boukari et *al.* (2022) and [13] Badou (2025) note that artisanal gold mining offers an alternative to the limited benefits of industrial mining, poverty and precarious living conditions. According to [21] Medinilla et *al*. (2020), artisanal mining has become a central activity in Burkina Faso's rural economy. Furthermore, the activity injects considerable quantities of gold into the global gold market [9], [16].

These economic dynamics are, however, accompanied by profound social transformations. In the commune of Ouahigouya, our findings reveal that gold panning primarily involves a young and poorly educated population, which aligns with the observations of Bohbot (2017)[8], for whom gold panning is above all a last-resort activity for populations facing a scarcity of formal jobs and agricultural precariousness. The work of Badou (2025) [13], conducted in the localities of Papara and Angovia in Côte d'Ivoire, reports an increase in social ills such as prostitution, compounded by the abandonment of agro-pastoral activities. Indeed, Sawadogo (2021) [22] illustrates this reality by highlighting that a landowner who was unable to generate 30,000 CFA francs per month from agricultural income finds himself tempted by the several thousand CFA francs obtained without any effort on his part, simply by leasing his land for mining. However, Tougma et al. (2025) [23] have noted that artisanal gold mining helps to reduce poverty in the short term, without, however, constituting a sustainable solution to escape precariousness.

4.2. Artisanal gold mining and environmental dynamics

Artisanal gold mining is a significant factor in environmental degradation. Indeed, several methods of gold prospecting and extraction were already in use during the pre-colonial period [22] (in Kiéthéga, 1983). However, the intensification of this activity in recent years has considerably amplified its impacts on the biophysical environment. In the commune of Ouahigouya, a diachronic study of vegetation cover, carried out using Landsat imagery from 2005 and 2023 via NDVI calculation, reveals a decline in vegetated areas at the two sites studied. This trend is confirmed by Google Earth Pro imagery (2006, 2013 and 2021). Sawadogo (2021) [22], in a similar study conducted in the municipality of Kampti, indicates that the observed degradation results in the gradual disappearance of wooded savannah, shrubby savannah and tree-dotted savannah. Similarly, Assoumane et *al.* (2025) [12] and Bombibambe et *al*. (2025) [24] demonstrate in their work that gold panning has become a key factor in land use, profoundly transforming rural landscapes to the detriment of agricultural land and natural areas

5. Conclusion

Gold panning is a long-standing activity in Burkina Faso, which has experienced significant expansion over the past two decades, particularly in the commune of Ouahigouya, driven by the combined effects of rising global gold prices and the fragility of local economic alternatives. This study, based on an approach combining field surveys of 108 individuals and a diachronic analysis of Landsat satellite imagery (2005–2023) and Google Earth Pro imagery (2006, 2013, 2021), has provided an understanding of the dynamics associated with gold panning. The results highlight the central role of gold panning as an economic coping mechanism for rural households, generating sometimes significant income within a hierarchical system of actors. However, these benefits remain highly unevenly distributed and are primarily driven by short-term subsistence needs, failing to guarantee a sustainable improvement in living conditions. Furthermore, the activity is accompanied by social changes (abandonment of agro-pastoral activities, precarious working conditions, presence of minors at the sites). From an environmental perspective, NDVI analyses reveal a decline in vegetation cover between 2005 and 2023, confirmed by observations from Google Earth Pro. Although this degradation occurs within a context of multiple anthropogenic pressures such as population growth, climate change…. Gold panning in the municipality of Ouahigouya thus illustrates a major paradox: that of an activity which is both essential to the economic survival of local populations and a major source of socio-environmental impacts. In this context, the implementation of policies tailored to the local context appears essential. These should, in particular, aim to formalise the artisanal sector, rehabilitate degraded sites, promote sustainable mining practices and strengthen local governance. In order to reconcile the imperatives of economic development with the preservation of the natural environment.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest. Compliance with ethical standards: This article does not contain any studies involving human or animal subjects.

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