

Research Article

Mining in Madagascar: Optimizing the Added Value with Gold Sector

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Abstract

In Madagascar, the mining sector accounted for 47% of exports and 5% of GDP in 2023. This is a key sector, but one that remains largely under-exploited for the country's economic development. However, industrial mining could account for up to 14% of Madagascar's GDP and dominate the country's exports by 2025. The objective of this study is to analyze and propose strategies to optimize value addition in artisanal and small-scale mining, with a focus on gold. Madagascar is rich in mineral resources such as graphite, nickel, cobalt, titanium and chromium. These resources are classified by international conventions as large-scale corporate mining. In addition to this type of mining, there is a sector dedicated to artisanal and small-scale mining (ASSE). It is this sector that is the focus of this study. ASSE is particularly important for Madagascar's national economy, as it provides jobs and income for local communities while contributing to the production of essential minerals. From an economic perspective, optimizing value added can also lead to a better distribution of the profits and revenues generated by mining, thus ensuring that local communities benefit equitably from the economic spin-offs of these activities. The existing exploitation does not improve the standard of living of the Malagasy people, but on the contrary increases the already existing poverty. The Commune is relieved of its gold resources, but these have no significant social or economic benefits. Finally, this study explores innovative models for local economic development and cooperation between public and private actors and civil society. It could serve as a reference for other similar contexts where artisanal and small-scale mining plays a central role in the regional economy. The main interest of this study is its ability to propose concrete and adapted solutions to improve the sustainability, profitability and positive socio-economic impacts of artisanal and small-scale mining in Madagascar's unique context. With a projected growth of 5.3% in 2025, the economic outlook is promising, and the mining industry's performance is expected to further boost this growth.

Keywords

Gold, Madagascar, Optimizing, Small-Scale Exploitation, Socio-economic

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1. Introduction

Madagascar has a rich subsoil teeming with precious resources such as sapphire and gold, which have helped to forge its international reputation for many years to this day. These precious stones and metals are major assets for the country's economic development, attracting substantial foreign investment. In order to coordinate Madagascar's various mining operations, i.e. the large-scale mining and artisanal and small-scale mining, the Ministry in charge of Mines and Strategic Resources is seeking to recast the new Code as a balanced response to the sector's multiple issues and new challenges in the light of changing trends in these sectors.

Under ASSE, the framework governing the gold sector recognizes two types of exploitation: the exploitation in mining squares conferred by mining permits reserved for small-scale miners, and the exploitation of gold in gold panning corridors. The Mining Code stipulates that small-scale miners must limit themselves to the use of artisanal techniques in carrying out their exploration and/or mining operations, without defining what these artisanal techniques are. However, the Ministerial decree 7903/2013 authorizes both manual and mechanized artisanal gold mining. There is a de facto inconsistency between the Mining Code and the ministerial decree [1].

2. The Dynamic Growth of the Mining Sector in Madagascar

The African Development Bank (AfDB) forecasts a significant economic upswing in Madagascar, driven primarily by the mining sector. According to the 2023 report, this sector could account for up to 14% of GDP by 2025, driven by growing demand for strategic minerals such as ilmenite, nickel and cobalt. Currently, ilmenite, nickel and cobalt mining contribute 1.5% to GDP, but their impact could increase substantially, reaching between 4% and 14% by 2025, and thus dominating national exports. Major investments by Rio Tinto in the south-east and Ambatovy in the east testify to the growing role of the mining sector, according to the AfDB [2].

Despite mainly artisanal mining, the AfDB believes that Madagascar could become a major player in African gold production. The small quantities of precious stones extracted by gold miners, such as sapphire, ruby and emerald, also contribute to this dynamic. Very few minerals in the north-west are identified as opportunities for private investment. According to the Extractive Industries Transparency Initiative (EITI) Madagascar, the AfDB report also highlights the significant economic contribution of the mining sector. In 2022, this sector accounted for 4.62% of GDP, playing a crucial role in exports (27.59%), government revenues (4.41%) and employment (1.82%). Despite global economic challenges, Madagascar's extractive sector is

maintaining sustained growth, boosted by increased demand for minerals following the repercussions of the war in Ukraine. According to the data from the Ministry of Economy and Finance, growth prospects are promising, with a forecast of 8.6% in 2023, followed by the projections of 14.6% in 2024 and 14.5% in 2025 [3-5].

To fully understand the value-added optimization strategies in the context of artisanal and small-scale mining in Madagascar, we examine the preconditions necessary for their effective implementation. This analysis focuses on the economic, social and environmental aspects that influence these strategies. Before exploring specific strategies, it is crucial to contextualize the unique challenges and opportunities presented by sapphire and gold mining in Madagascar.

3. Geo Political Trend in the Gold Sector

The Artisanal and Small-scale Gold Mining (ASGM) sector is a complex and constantly evolving field, shaped by a range of geopolitical factors.

3.1. Rise of Non-state Actors

This statement highlights the critical problem in gold-producing regions like the growing involvement of non-state armed groups, the militias and the criminal organizations in this sector. This is a worrying trend, as it often undermines the authority of local governments and increases levels of conflict and instability. The non-state armed groups, the militias and the criminal organizations are also playing an increasingly dominant role in Artisanal and Small-Scale Mining, often to the detriment of government authorities and local communities. This trend risks to intensify conflict and instability in the regions where gold mining is important. [6]

3.2. Demand for Gold

Demand for gold is driven by economic growth, inflation and geopolitical uncertainty. This dynamic should support gold prices and stimulate the artisanal and small-scale mining activity, but it could also lead to an increase in illegal mining and have negative impacts on the environment. Due to economic and geopolitical factors, the increase in demand for gold is therefore to benefit artisanal and small-scale mining, while highlighting the risks associated with a possible increase in illegal mining and its environmental consequences [6].

3.3. Accumulated Scrutiny on Sustainability

Growing consumer and investor concerns about the social and environmental impacts of mining and related activities should push the Governments and the companies to adopt more sustainable practices. However, this development could

lead to an increase in the cost and complexity of operations in the ASSE sector [6].

3.4. Evolution of Technologies

New technologies such as artificial intelligence and block chain present transformational potential for the ASSE sector. They can significantly improve the efficiency, transparency and traceability of operations. However, the adoption of these technologies can also create new challenges in terms of governance and cybersecurity, as well [6].

4. Regional and International Agreements in the Gold Sector: Case of ASSE

Regional and international agreements play a crucial role in the regulation and the management of the ASSE sector. Generally, these agreements aim at promoting sustainable practices, strengthening governance and improve working and environmental conditions in mining areas. At regional level, several organizations and agreements, such as the Economic Community of West African States (ECOWAS) in West Africa or the Andean Community in South America, have developed frameworks to regulate ASSE.



Figure 1. Malagasy's Artisanal and Small-Scale Exploitation.

These frameworks often include guidelines for the formalization of mining operations, the management of natural resources and the reduction of environmental impacts [1, 7].

In addition, agreements like the Nagoya Protocol on Access to Genetic Resources and Benefit Sharing may also have implications for mining practices. Despite these initiatives, ASSE often remains influenced by complex local dynamics, including challenges such as corruption, poverty and limited access to cleaner technologies. However, regional and international cooperation remains essential to encourage responsible and sustainable practices in this vital but often problematic sector.

5. Macro-Economic Trend in the Gold Sector

ASSE sector is effectively influenced by a set of macroeconomic factors that play a crucial role in its evolution and outlook. Four of the most important trends to watch out for in the coming years are, in succession.

Madagascar is committed to accelerate the structural transformation of its economy. Industrialization and economic transformation are a major pillar of the General Policy State (GPS) 2024-2028, adopted in January 2024. This pillar includes all of Madagascar's growth-generating sectors (industrialization, telecommunications, mining, agriculture, tourism, transport and energy infrastructures). With regard to industrialization in particular, the country intends to develop its industrial sector, building on its strengths, notably competitive labor costs, the availability of raw materials, and targeted growth sectors (agro-industry, textiles and clothing, essential oils, mining, energy) [8].

Table 1. Resources and main objectives.

Resources (*1 000 Ariary)	Main objectives
Budget 2023: 19,821,819	Increase rational management of the mining sector
Budget 2024: 18,289,262	
Budget 2025: 39,531,216	Control the value chain in the gold industry
Budget 2026: 53,620,723	

5.1. Gold Prices

ASSE is an activity often associated with gold mining in many parts of the world. As mentioned, before the price of gold plays a crucial role in the profitability of this activity. When the price of gold rises, it tends to stimulate ASSE activity. Why is this? Because an increase in the price of gold means that every gram or ounce of gold extracted is worth more in the market. The artisanal and small-scale miners can then be more motivated to step up their extraction activity. This can lead to an increase in the number of people involved in mining, as well as more investment in new mining operations.

5.2. Economic Growth

Global economic growth plays a crucial role in determining the price of gold, which has a direct impact on the ASSE sector. In times of robust economic growth, demand for gold tends to increase for a number of reasons. Gold is often perceived as a safe haven in times of economic or geopolitical uncertainty. When investors seek to protect their capital, they may turn to gold, increasing demand and driving up prices. Gold is also used in a variety of industrial sectors, including

electronics, jewelry and medical technology. Sustained economic growth can stimulate demand in these sectors, contributing to an increase in demand for gold and thus to higher prices.

5.3. Exchange Rates

The exchange rate between the local currency and the US dollar is a critical factor influencing the profitability of ASSE in gold-producing countries. When the local currency appreciates against the US dollar, it means that each unit of local currency generates fewer US dollars when converted. For local gold producers who sell their production in dollars, an appreciating local currency can reduce their income in local currency terms, making mining less profitable. This can put pressure on miners' profit margins, as their local costs often remain fixed while their dollar revenues decline. Conversely, a depreciation of the local currency against the US dollar can have a positive effect on ASSE's profitability. A depreciation means that the dollar revenues generated by the sale of gold increase when converted into local currency.

6. Gold Analysis Tools

Madagascar has significant gold deposits, mainly concentrated in the northeast and southeast of the country. Gold analysis tools play an essential role in assessing the quality and quantity of gold extracted, as well as in the management of mining operations. Gold analysis tools in Madagascar play a vital role in many aspects of mining, from natural resource management to local economic impact. By providing accurate data on the quality and quantity of gold extracted, these tools help to optimize extraction processes, ensure regulatory compliance and maximize the profitability of mining operations. They also contribute to the sustainable management of natural resources by enabling accurate assessment of the environmental and social impacts associated with mining operations.

6.1. Gold Data Sheet

Madagascar has significant gold potential, mainly mined by artisanal methods. However, mining presents environmental and socio-economic challenges that must be managed sustainably to maximize benefits while minimizing negative impacts.

Gold properties:

1. Chemical symbol: Au
2. Atomic number: 79
3. Atomic mass: Approx. 197 g/mol
4. Melting point: 1,064.18°C
5. Boiling point: 2,856°C
6. Density: 19.32 g/cm³ (at 20°C)
7. Color: Bright yellow - orange yellow
8. Hardness (Mohs scale): 2.5 - 3

9. Electrical conductivity: Very high

10. Thermal conductivity: Very high

11. Chemical reactivity: Very low, unalterable to air and most chemical agents

Gold is truly fascinating in many ways. Its high density and excellent electrical and thermal conductivity make it a unique material in many fields, from electronics to jewelry. Its rarity and resistance to corrosion also make it a valuable choice for long-term investments. Its distinctive color and relative softness on the Mohs scale (a mineral hardness scale invented by German mineralogist Friedrich Mohs in 1812) add to its aesthetic appeal and ease of handling [9].

The artisanal gold mining is widespread in Madagascar, with operations often informal and sometimes illegal. Extraction techniques vary from small-scale manual mining to the use of more modern methods, in certain areas.

6.2. Gold Geology

Madagascar is composed of ancient and complex rocks, resulting from a variety of geological processes including metamorphism, volcanism and sedimentation. These processes have contributed to the formation of gold deposits in different areas such as the Antanimbary Region, the Ampanihy Region and the Mananjary Region. Gold deposits in Madagascar mainly comprise alluvial deposits, where gold is transported and concentrated by rivers and streams. There are also primary deposits associated with mineralization in metamorphic and volcanic rocks.

Gold mining in Madagascar is mainly artisanal and informal. Although some efforts have been made to promote more structured and regulated mining. In Madagascar, the gold mining still remain artisanal and informal. Thus, Madagascar's gold geology thus offers a diversity of alluvial and primary deposits in different regions, representing both opportunities and challenges for economic development and natural resource management.

6.3. Gemological Considerations of Gold

The geology of gold is a complex field, involving the study of the geological processes that lead to the formation of gold deposits.

Primary deposits: Gold often forms in specific geological conditions, such as fault zones, metamorphic rocks (like schists), and hydrothermal zones where mineral-rich fluids precipitate gold.

Secondary deposits: These are formed when gold is transported by geological processes (such as erosion and sedimentation) and concentrated in alluvial deposits, such as gold placers.

Gold occurs mainly in native (pure) form, often as nuggets or flakes, but can also be associated with other minerals such as pyrite, chalcocopyrite or quartz.

Gold deposits can form in subduction zones, where

gold-rich hydrothermal fluids are released from molten rocks. There are also green schists and metamorphic shales, where these environments are often associated with primary gold deposits, and placers: alluvial deposits resulting from the erosion and concentration of gold in river beds and gravel deposits.

Geological exploration uses various techniques, such as geological mapping, geochemistry, geophysics and numerical

modeling to locate potential gold deposits. Gold can be extracted from ores using open-pit mining or underground methods such as blasting, crushing and cyanidation. Gold is of major economic importance due to its intrinsic value and its use in jewelry, electronics and other industrial applications. Gold mining can have significant environmental impacts, including deforestation, water pollution and loss of biodiversity, requiring rigorous management and regulation [10].

Table 2. Statistics on formally registered collectors and approximate collectors.

Communes	Number of collectors	2018	2019	2020	2021
Maevatanana I	Registered Commune	22	08	07	06
	Approximate	35	35	35	35
Beanana	Registered Commune	-	-	3	3
	Approximate	-	-	40 to 60	40 to 60
Antsiafabositra	Registered Commune	-	-	10	10
	Approximate	100	100	100	100
Andriba	Registered Commune	0	0	0	0
	Approximate	8 to 10	14	17	17
Antanimbary	Registered Commune	-	13	2	0
	Approximate	66	64	64	60

As The [Table 2](#) shows that:

1. For Maevatanana I, the number of registered collectors is decreasing every year, for tax reasons. In 2021, there will be 6 formal collectors, representing 17% of the Commune's approximate 35 collectors;
2. for the Communes of Beanana and Antsiafabositra, registered collectors represent, respectively, 5% and 10% of the approximate number of collectors;
3. for the Communes of Andriba and Antanimbary, no collectors are recorded in the collector register. However, for Antanimbary, an analysis of its administrative ac-

counts revealed the number of collectors who had paid the card fee. Therefore, his number is considered as the number of collectors registered at Commune level. This proportion represents 3% of the approximate number of collectors in 2020.

At present, production is sporadic and irregular, often coming from informal sectors.

The production statistics below are not meaningful, as they relate solely to statistics declared to the Mining Administration.

Table 3. Shortfall in collector's card fees for 2021.

Headings	Maevatanana I	Beanana	Antsiafabositra	Andriba	Antanimbary
Collector card fee (MGA): A	200 000	200 000	200 000	200 000	200 000
Number of registered collectors: B	6	3	10	0	0
Approximate number of collectors: C	35	40 to 60	100	17	60
Card fees collected (MGA): D = A * B	1 200 000	600 000	2 000 000	0,00	0,00
Card fees to be collected (MGA): E = A * C	7 000 000	8 000 000 to 12 000 000	20 000 000	3 400 000	12 000 000

Headings	Maevatanàna I	Beanana	Antsiafabositra	Andriba	Antanimbary
Shortfall (MGA)					
F = E – D	5 800 000	7 400 000 to 11 400 000	18 000 000	3 400 000	12 000 000

Table 3 shows a significant shortfall in collector card fees for 2021. This shortfall is due to under-reporting of the number of active collectors in the communes studied. In the

case of Maevatanàna I, for example, losses amount to MGA 5,800,000, whereas the actual number of collectors is estimated at between 35 and 60, far more than the 6 registered.

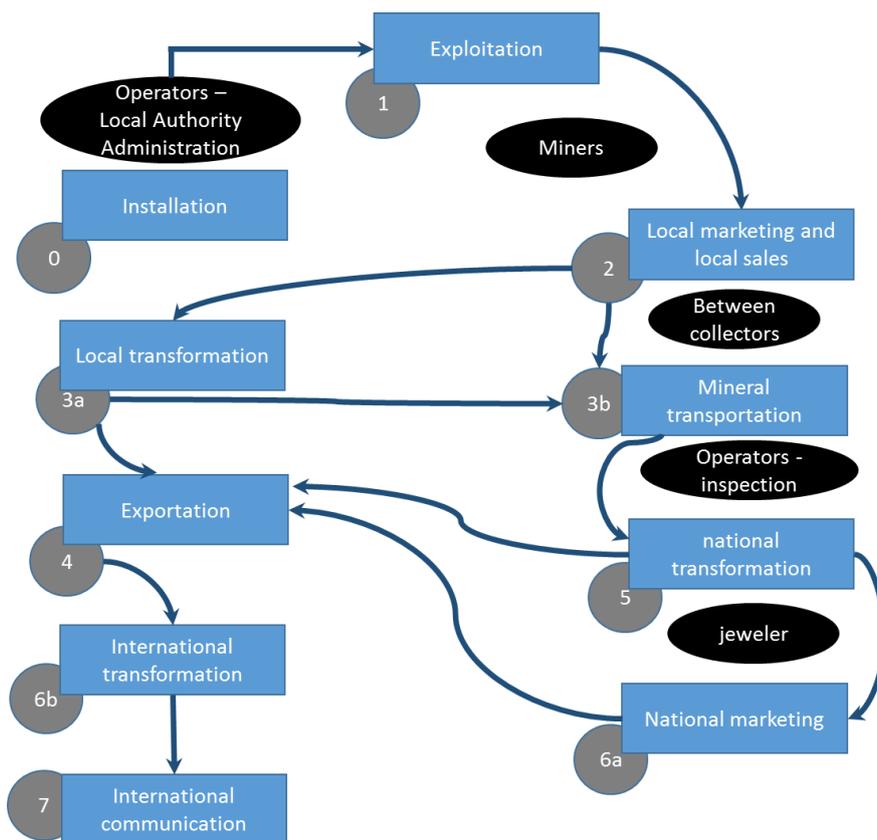


Figure 2. Presentation of different gold panning activities.

7. Conditions for Implementation

The following section examines in detail the essential conditions for the effective implementation of strategies aimed at optimizing value-added in artisanal and small-scale mining. We focus particularly on the specific cases of sapphire and gold in Madagascar, highlighting the unique challenges and opportunities in these sectors. This section examines the local and global factors that shape these industries and influence strategic decisions aimed at maximizing value-added. His part of the report consequently aims to identify the conditions necessary for successful value-added optimization strategies in artisanal and small-scale mining. Based on the examples of

sapphire and gold mining in Madagascar, it seeks to identify best practices and recommendations for sustainably improving the profitability and social impact of these sectors.

7.1. CAPEX

CAPEX is an essential pillar in the strategy of ASSE players, fostering sustainable growth, innovation and customer satisfaction. By investing wisely in its physical assets, the company strengthens its image as a responsible operator, and prepares itself to successfully face market challenges and opportunities.

While CAPEX expenditure represents an initial investment, it generates considerable savings over the long term. Indeed, optimizing processes and improving energy performance help

to reduce operating costs and increase overall profitability.

For ASSE, this includes the purchase of servers, hardware, data security solutions and IoT devices. As part of the implementation of a defensive strategy aimed at preserving its position in the Mining Administration and this sector, ASSE plans to increase its CAPEX investments, motivated by several key factors:

1. Strengthening technological infrastructure
2. Improving performance and reliability

3. Optimizing costs and profitability

4. Anticipating market trends and needs

By remaining at the forefront of technological innovation, ASSE is well positioned to respond to market developments and emerging customer expectations. This proactive approach enables the company to maintain its leadership and project itself serenely into the future.

The [table 4](#) below shows the CAPEX required to deploy our strategy of fortifying governance in the ASSE sector:

Table 4. CAPEX for strategy implementation.

Accounts	Description	Q	Total price (KMGA)
218 Other tangible fixed assets	Server	1	45 000
218 Other property, plant and equipment	Network equipment	1	15 000
204 Computer and related software	System security	1	75 000
218 Other property, plant and equipment	HP 92R24EA computer	2	8 000
218 Other property, plant and equipment	Office chair	2	1 200
218 Other property, plant and equipment	Office table	2	1 684
218 Other property, plant and equipment	Storage cupboard	1	530
	Prospecting and mining equipment		25 000
	Processing equipment		30 000
Purchases of work equipment	Safety equipment		20 000
	Support infrastructure		150 000
			371 414

7.2. OPEX

Besides, OPEX represent expenses related to day-to-day operations. This includes the day-to-day costs of running the business, such as salaries, rental costs, maintenance, insurance, marketing expenses, etc.

OPEX must directly contribute to strengthening the competitive position of TAG-IP, by supporting strategic objectives such as innovation, customer satisfaction, and operational efficiency.

The [Table 5](#) below represents the OPEX to be planned for the deployment of our fortification strategy:

Table 5. OPEX.

Accounts	Designation	Amount (KMGA)
605 Purchases of materials	Purchases of materials	120 000
	GPS modules	
	DMS system	
607 Purchases of goods	Purchases of goods	39 200
	Probes	
	Cameras	

Accounts	Designation	Amount (KMGA)
613 Rentals	Cloud storage space rentals	20 000
613 Rentals	Workspace rental	2 000
615 Upkeep, repairs and maintenance	Upkeep, repair, maintenance of computer equipment and after-sales service	8 000
616 Insurance premiums	Insurance premiums	6 000
617 Studies and research	Research and development	5 000 000
623 Advertising, publication, public relations	Advertising, publication, public relations	5 000 000
626 Postal and telecommunications costs	SIM and data subscription	8 400 000
641 Staff remuneration	Salary and benefits to employees	51 000 000
647 Other social charges	Staff training	10 000 000
651 Software royalties	Software subscription	10 000 000
606 Non-inventory purchases of materials and supplies	Office supplies	400 000
602 Other supplies	IT consumables	500 000
625 Travel, missions and receptions	Travel expenses, missions	2 000
606 Non-stocked purchases of materials and supplies	Fuel	3 600
606 Non-stocked purchases of materials and supplies	Water and electricity	1 800
	Initial training	3 000
Employee training	Training of supervisors and managers	2 000
	HSE	1 500

Furthermore, Madagascar remains among the poorest countries in the world. According to some economists, artisanal mining could potentially generate more than ten billion dollars in turnover. However, in reality, these farms contribute little to state revenue because the added value is often recorded outside the country. An immediate solution would be to

record this added value in Madagascar [11]. Although the formal extractive sector makes a significant contribution to the national economy, as illustrated in Table 6 showing its contribution to Madagascar's Public Investment Program, there remain significant challenges to maximize benefits for the country.

Table 6. Contribution of Extractive Industries to Madagascar's GDP (in %).

	2019	2020	2021
GDP Madagascar	21 880,90	20 626,90	21 212,60
Contribution of the Extractive Sector	1 402,60	738,40	1 025,20
Contributions of Extractive Industries to GDP (%)	6,41 %	3,58 %	4,80 %

As we can see in the Table 6, in 2019, the contribution of Extractive Industries to GDP was 1,402.60 million Ariary, decreasing to 738.40 million Ariary in 2020 before increasing slightly to 1,025.20 million Ariary in 2021. This fluctuation may reflect variations in production or in the prices of extracted raw materials. In terms of percentage of GDP, the extractive sector

accounted for 6.41% of GDP in 2019, decreasing to 3.58% in 2020, then increasing to 4.80% in 2021. This indicates a significant but variable contribution of the extractive sector to the overall economy of Madagascar during these years. The decline observed in 2020 could be attributed to various factors such as the COVID-19 pandemic and its impacts on economic activities,

including those of the extractive industries. The recovery in 2021 could indicate a stabilization or resumption of activity in this crucial sector for the national economy [3].

7.3. Contribution of Extractive Industries to the GDP

Figure 2 highlight the importance of the extractive sector in Madagascar's economy, although its contribution fluctuates from year to year due to various internal economic and exter-

nal factors. In this vein, we will overlap with the figure which will represent the contribution of extractive industries in the GDP of Madagascar (in %).

Recently, the data reveals a notable regression in the contribution of extractive industries to Madagascar's GDP, falling from 6.41% in 2019 to 3.58%. This significant decrease can be attributed to the devastating impact of the COVID-19 pandemic on the sector. On the other hand, a slight recovery is observed in 2021, with a contribution of 4.80% to GDP, indicating a gradual resumption of extractive activities.

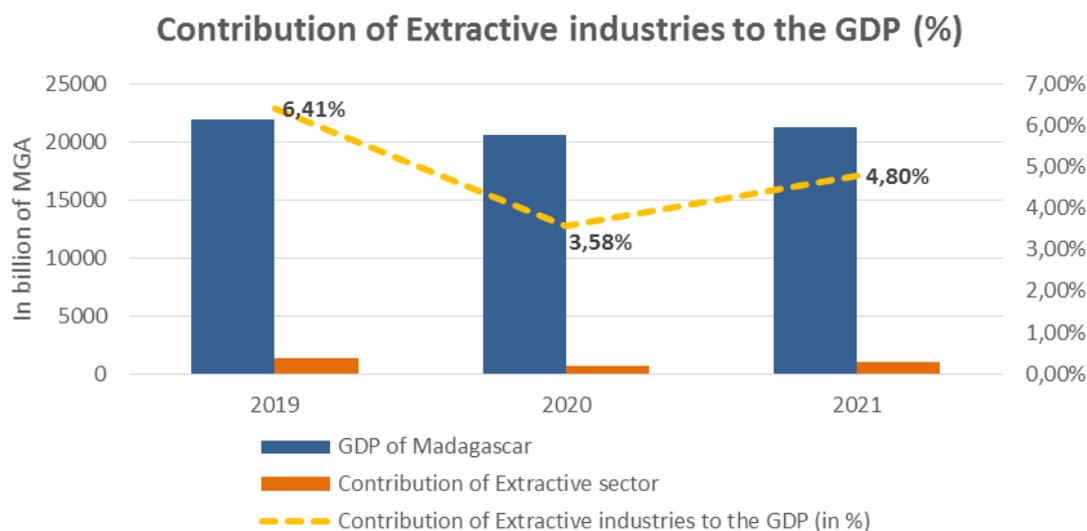


Figure 3. Contribution of Extractive industries to the GDP (in %) of Madagascar.

According to the customs statistics, these analyzes will lead us to study the evolution of the contribution of revenues from the extractive sector to Madagascar's exports.

Table 7. Contribution of Extractive Industries to Madagascar's exports.

	In billions of MGA		
	2019	2020	2021
Exports from Madagascar	9 674,79	7 554,12	10 558,20
Contribution of extractive industries	2 828,73	1 384,64	3 400,10
Contribution of Extractive Industries in %	29,24%	18,33%	32,20%

It is interesting to note the evolution of the contribution of extractive industries in Madagascar's exports during the years 2019 to 2021. In 2019, Madagascar's total exports were MGA 9,674.79 billion, among which extractive industries contributed MGA 2,828.73 billion, representing 29.24% of total exports. In 2020, exports decreased to MGA 7,554.12 billion, with a contribution from extractive industries of MGA 1,384.64 billion, representing 18.33% of the total. In 2021, exports in-

creased significantly to MGA 10,558.20 billion, and the contribution of extractive industries also increased to MGA 3,400.10 billion, accounting for 32.20% of the total.

Recently, the data reveals a notable regression in the contribution of extractive industries to Madagascar's GDP, falling from 6.41% in 2019 to 3.58%. This significant decrease can be attributed to the devastating impact of the COVID-19 pandemic on the sector. On the other hand, a slight recovery is

observed in 2021, with a contribution of 4.8% to GDP, indicating a gradual resumption of extractive activities [11].

7.4. Extractive Industries in Exports

Now, we move on to the study on the contribution of the extractive industries to Madagascar's exports. This analysis will make it possible to understand the economic impact and strategic implications of this crucial sector for the national economy.

In 2019, exports from the extractive sector in Madagascar reached MGA 2,828.73 billion, marking a positive performance. In 2020, a decrease of 10.91 points compared to 2019

was recorded. However, in 2021, a resumption of extractive activities was observed, with a share in exports reaching 32.20%. As for the informal extractive sector, according to the report entitled "ASM Sustainable Development Strategy" from GIZ (December 2018), the latest official estimate from the Ministry of Mines dates back to 2015 [10, 11]. This estimate indicates that this sector employs around one million workers, including farmers who practice these activities during non-agricultural seasons. The artisanal and Small-Scale Mining (ASM) includes operations using artisanal techniques as well as gold miners, whether formal or informal, in accordance with the international definition.

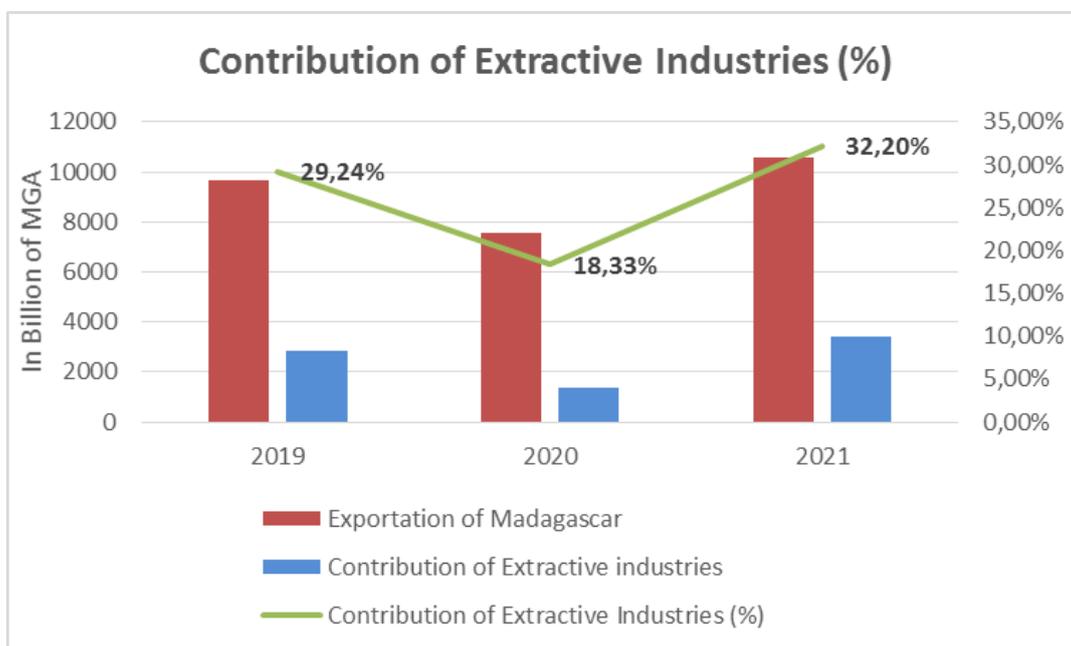


Figure 4. Weight of extractive industries in exports (in %).

This process will lead us to map areas according to the concentration of artisanal gold mining activities, thus allowing a better understanding of the geographical distribution and socio-economic impact of these informal mining operations.

8. Growth Rate of GDP, Real and Forecast from 2025 to 2028

Economic growth at the end of 2025 is projected at +5.0%. This performance should be underpinned principally by the performance of the agricultural sector, the effects of recent reforms (notably the application of the new mining code, liberalization in the telecoms sector), the normalization of the situation in the mining sector, and tourism activities at levels expected to be higher than in 2019 [12].

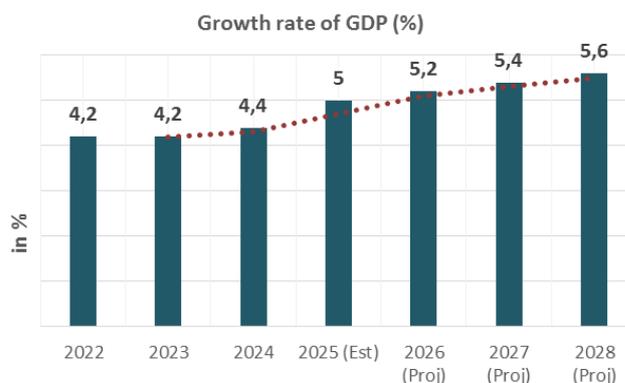


Figure 5. Weight of extractive industries in exports (in %).

Authors has designed a Monitoring and Evaluation System

that is intended to track progress toward achieving intended outcomes.

In order to optimize added value in mining, figure 5 below

show the web-based system allows responsible to carry out and to monitor in real time all the situation concerning the Gold, using any web-enabled device.



Figure 6. The artisanal gold mining supervision in Madagascar.

The main objective is to identify and track the evolutionary movement that can produce a long-term effect on the gold sector. Several factors influence the market: long-term trends and short-term fluctuations. These factors include the dynamics of supply and demand and especially government policies, international transactions and the environment. The trend in the financial market will be estimated using moving averages or trend lines:

1st case: If gold is in an uptrend, we consider using a trend-following strategy.

2nd case: If gold is in a downtrend, we will look for potential short selling opportunities in the market.

9. Conclusion

The artisanal gold mining in Madagascar represents both a source of considerable economic potential and complex challenges. To maximize economic benefits while minimizing negative social and environmental impacts, it is imperative to adopt policies and practices that promote the formalization of the sector. The adoption of sustainable technologies, improved access to finance and technologies, as well as the responsible promotion of artisanal gold. In fact, Madagascar could transform its gold resources into sustainable engines of economic development, while preserving its natural environment and improving the living conditions of local mining communities.

The tax pressure rate is 10.4% on average over the period

2015-2023, while the tax potential is estimated at 17% of GDP, with significant tax loopholes (mining, fishing, forestry, tax exemptions). While the adoption of a new mining code and a new investment law in 2023 should revitalize the sector, and encourage investors to intervene in mining industrial transformation [11, 12].

The Malagasy economy is characterized generally by agricultural sector, the service with low productivity sector and a small but fast-growing industrial sector. The country has comparative advantages in mining, textiles and clothing, agribusiness, fisheries, and IT/business process outsourcing. In short, even having natural resources, public power has not been able to exploit all the profitable parameters to accelerate the structural transformation of its economy.

Abbreviations

AfDB	African Development Bank
ASGM	Artisanal and Small-scale Gold Mining
ASSE	Artisanal and Small-Scale Exploitation
CAPEX	Capital EXpenditures
ECO-WAS	Economic Community of West African States
EITI	Extractive Industries Transparency Initiative
GDP	Gross Domestic Product
GPS	General Policy State
OPEX	Operational Expenditures

Author Contributions

Andriamiadanomenjanahary Harivelo Chandellina Camille: Conceptualization, Investigation, Supervision, Data curation, Writing – review & editing

Rakotoarisoa Marie Eliane: Conceptualization, Resources, Methodology

Randrianasolo Herilalaina Fabien: Resources, Methodology

Rafamantanantsoa Andriamananipiarivo Hasina: Resources, Methodology

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography



Andriamiadanomenjanahary Harivelo Chandellina Camille is a professor in the Department of Cognitive Science in ESPA (Polytechnic High School of Antananarivo), in the Department of Telecommunication in IESAV (High School Institute of Antsirabe), and ENAM (National Administration School of Madagascar). He completed his PhD in Cognitive Sciences from STII University of Antananarivo in Dec 2017. He completed also his Master of Telecommunication from Polytechnic High School of Antananarivo in 2014 and Master of Computer Science Engineer from National Computer School of Fianarantsoa in 2004. Recognized for his exceptional contributions, his research interests span both Science Cognitive, Data and Big Data Analysis in local and cloud. In the economy research, he has worked on Micro, Mezzo and Macro Economy of Madagascar and also econometric. In addition he has made numerous contributions to IA, has focused on the big data analysis, economy, and optimization of decision making.



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Rafamantanantsoa Andriamananipiarivo Hasina is a career diplomat working for the Ministry of Foreign Affairs in Madagascar, supporting sectoral development projects. Before becoming a diplomatic and consular agent, she studied at the Ecole Supérieure des Sciences Agronomiques de Madagascar, graduating in 2001 with a diploma in Agronomic Engineering, specializing in livestock breeding. In 2003, she continued her specialization in France at the Institut National Agronomique de Paris-Grignon, in the Geography and Development Practice department. In addition to her position at the Ministry, she has also worked for several years as Regional Coordinator of the Office National de Nutrition in the south of Madagascar, in the fight against malnutrition and in partnership management.

Research Field

Andriamiadanomenjanahary Harivelo Chandellina Camille: Artificial Intelligence, Data and Big Data analysis, Economic, Mathematic, Management, Operational Research (optimization), Telecommunication.

Randrianasolo Herilalaina Fabien: Management, sociology, agronomy, financial administration, economics, tourism, engineering, territorial planning, legal science, diplomacy.

Rakotoarisoa Marie Eliane: Management, public finance, import and export, financial administration, chemistry, economics.

Rafamantanantsoa Andriamananipiarivo Hasina: Public finance, sectoral development, financial administration, agro-economics.