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Artisanal and small-scale mining in Tanzania and health implications: A policy perspective

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ABSTRACT

The mineral sector, especially its small-scale subsector, has become significant in the emerging economies of the Global South. Tanzania is the focus of this policy exposition paper because, aside from Ghana and South Africa, Tanzania is ranked 4th in Africa in terms of its mineral deposits and small-scale mining activities. The focus is also on artisanal and small-scale mining (ASM) because ASM operations have significantly increased in recent times across this mineral-rich country of East Africa. This is done against a negative backdrop-labelling of ASM as unsustainable, environmentally unfriendly, inefficient, and illegal. Tanzania has made some progress to respond to some of the challenges in the mining sector to improve the micro and macroeconomics of the country. Some areas remain challenging including the lack of proper environmental health education for the ASM miners; the lack of clear national-level policies to guide health-related matters in the ASM subsector, and the small capital investment of the ASM subsector to support healthy mining practices. The details related to the persistence of these challenges are not well known, particularly those that pertain to policymaking. This article attempts to evaluate the policy environment of the ASM subsector in Tanzania and propose appropriate actions for the future of mineral resource policymaking in Tanzania.

1. Introduction

1.1. General overview

In Tanzania, it is estimated that more than one million people are directly involved in artisanal and small-scale gold mining (ASGM), which is a subset of the artisanal and small-scale mining (ASM). Out of this, approximately 48.27 and 24.13% are men and

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children, respectively, while 27.60% are women [1]. This is because the mining and mineral sector is one of the essential areas of the economy, as is the case in most emerging economies [2]. When ASM is done responsibly, especially when its activities are combined with good governance, there is a chance that people, communities, and entire nations may profit greatly on the social and economic fronts. It is found that with good governance, the utilization of mineral resources would be expected to contribute considerably to sustainable development [3–5]. Notably, some African nations such as Namibia and Botswana have been role models in terms of mineral resources use for improving the welfare of micro- and macro-level economies; howbeit the story is different in most other sub-Saharan African nations [6]. Therefore, ASM is a way of life, not just a sector of the economy with the potential to increase employment and foreign exchange revenues. Undoubtedly, ASM employs millions of people globally, of which about 11.5–13 million people work directly in the sector and that up to 100 million rely on it for their livelihoods [7].

However, there have been constant criticisms from the ASM subsector and people contiguous to mineral resources attributable to the slight profits compared to the socio-environmental calamities that the ASM operations carry [8]. It is in the ASM subsector, where serious environmental worries have regularly been reported [9,10]. The reproductive well-being risks associated with ASM involve the intake or exposure to heavy metals [11–15]. For instance, in gold ASM, a large amount of mercury and other toxic chemicals are released into the environment and this problem is the same in Asia and Africa as it is in South America [16]. According to the World Health Organization (WHO), excessive exposure to mercury and other heavy metals is harmful to all lifeforms and humans are at the apex through the food chain [17].

The exacerbation of environmental damage due to ASM in Tanzania has been extensively reported, including its effects on human health [11,12,14,18–21]. Although pieces of scientific evidence have revealed that the environmental and human health impacts related to ASM are real, in this study we argue that the introduction of more strict government instruments alone will not necessarily end these problems. Despite the environmental challenges inherent in the ASM subsector, it could create reliable economic revenues under a suitable, effective institutional and legal framework [22–24]. However, the challenge has always been the lack of emphasis on community health, policy formulation, decisions making, and investment in the mining sector for viable and sustainable economic growth. Therefore, we suggest participatory approaches for Tanzania in the institutionalization/formalization of the mineral sector and the ASM subsector in particular.

Since the 1990s, Tanzania has embarked on a journey to redefine its policy landscape relating to mineral operations in the country. On the contrary, the review and updating of Tanzania's mineral policy and legislative environment have not been significantly translated into the expected social and economic transformation [8]. Tanzania's Mining Policy of 2009 was intended to stimulate viable exploitation and improvement of mining accomplishments by revamping the country's refined and processed mineral content. Also, the Policy aimed at upgrading the ASM subsector to substantially contribute to sustainable development among the ASM communities and beyond. However, to date, the situation of small-scale miners and their surrounding communities has not significantly reversed to make a better turn. Hence, little is alleged in policies and regulations on how to deal with environmental contaminants such as emerging chemicals of concern and hazardous materials.

Therefore, this work seeks to contribute to filling in the existing gaps in Tanzania's mining policies and regulatory framework. Consequently, this work seeks to touch on the following questions: What is the position of the scientific findings and the contribution of the broader scientific community in the formation of mineral policies, laws, and regulations in Tanzania? What are the environmental and public health implications pertinent to the ASM subsector legislation? How inclusive is the mining and mineral policymaking in Tanzania? What can Tanzania learn from sub-Saharan African and other mining economies? This study is a small contribution to the dialogue on sustainable policymaking for the mining sector especially in developing parts of the world using Tanzania as an example.

1.2. Contextualizing the ASM subsector

Small-scale gold mining (ASM) consists of a complex interaction of environmental, social, technological, economic, and health dynamics that can differ significantly depending on the prevailing international, national, and local settings [1]. These complexities make it challenging to formulate constant definitions. The ASM is broadly defined in the Minamata Convention on Mercury as 'gold mining conducted by individual miners or small enterprises with limited capital investment and production' [25]. The International Labour Organization (ILO) defines ASM as 'labour-intensive, with mechanization at a low level and basic' [26,27]. Constructing on this description, the World Bank's Communities, artisanal and small-scale mining initiative explains the social and economic consequence of artisanal and small-scale mining effort as "essentially a poverty-focused activity, usually done in the remote area of the country characterized with poor residents by mostly nomadic, poorly educated inhabitants with slight other employment choices" [28]. These classifications of ASM show some common features such as labour-intensive work, limited use of mechanical tools, an informal work sector, low investment and production, and deposit exploitation, with the limited environmental benign, market, and access to land [2, 29].

1.3. Global public health aspects of ASM

Small-scale mining activities have been recognized as one of the probable causes of exposure to heavy metals, trace elements, and other toxic substances [30–33]. However, in many developing nations, mining firms as well as ASM communities do not receive proper messaging on the controls for heavy metals and other toxic substances in the environment. In many sub-Saharan African countries, there are no clear policy guidelines and recommended dose limits that have been established by the environmental safety commissions and other responsible bodies [34–37]. With the current increase in awareness of the possible contact circumstances of heavy metals and other toxic substances, many developed countries are modifying and/or establishing regulations to put in place policies to regulate

environmental contaminants. For example, after the European Union (EU) Council Directive 96/29/EURATOM of May 13, 1996, where distinctive endowments regarding contact with toxic pollutants were introduced, a system was to be formed to support member countries to share skills and also to pinpoint and stimulate decent practices in the EU [38,39]. Whereas developed countries have recognized heavy metals with possible levels and actions being taken to address the subject, little is being done in developing countries. It is also worth noting that most of the activities that release heavy metals such as mining and mineral processing, gas and oil exploration, and extraction are located in developing countries. Different studies have also reported higher concentrations of heavy metals in the environment due to ASM activities [18,20,38,39]. The exposure to high levels of heavy metals and other toxic chemicals including mercury and cyanide due to small-scale gold mining activities is detrimental to human health and the environment [11–15].

However, in Tanzania, there are gaps in the regulatory and legal handling of the mining sector and long-term supervision of ASM operations [34,35,37,40]. Such gaps include the lack of appropriate policies, regulations, or laws in a manner that they can be practically implemented. These gaps have generally led to sustainability concerns such as poor public health and environmental degradation, challenges that are likely to remain the same for a long time [41,42].

In efforts to address some of the policy-based challenges, Tanzania has passed laws and keeps publishing different regulations and guidelines built on the best practices. While laws and regulations addressing conventional mining sustainability issues in Tanzania are available [35], these documents are lacking on ASM-specific stipulations. The absence of a regulatory framework in the ASM subsector adversely affects the efforts to achieve relevant sustainable development goals, which need to be addressed.

1.4. ASM policy formulation and regulatory framework in Tanzania

The environmental and public health issues in the ASM sector must be addressed in an organized manner. In addition, protection and control measures must be implemented without jeopardizing the health and economy of those directly affected by ASM activities. There are connections within the ASM environment and if the movement of people, equipment, mined ores, and rocks are not carefully monitored, the health and safety of ASM miners may be put in danger. For example, the equipment used for material excavation in ASM-based activities are usually poor and rudimentary, but also material transfer is usually handled using equipment that can accelerate exposure to trace elements and heavy metals. In some instances, ore crushers, for example, could be found to produce an enormous amount of dust at ASM sites. In other instances, it could be found that the ASM miners do not use protective gear, e.g., masks. When leaching the ores to recover the precious metals, ASM workers normally use bare hands and, sometimes, there are infants and children in the vicinity of the leaching areas.

Table 1 also summarizes the operations and guidelines of conventional mining companies and those of ASM. The major differences between the ASM and conventional mining subsectors were collected and collated from different documents in the literature as well as a field visit by authors to some of the ASM and conventional mines in Tanzania.

When considering Table 1, the following aspects of similarity can be evaluated:

- Both conventional mining and ASM raise concerns regarding environmental consequences, health risks, and safety issues.

Table 1
Difference between ASM and conventional mining subsectors in Tanzania.

Factor	ASM	Conventional mining
Capital	ASM mining processes are more labor-demanding and use less sophisticated technology.	Conventional mining requires a lot of funds in terms of initial capital and is reliant on sophisticated technologies.
Institutionalization	Co-operatives and traditional authority are among the informal and customary structures that make up ASM.	Formal and standard corporate structures, as well as public stock exchange listings, help to institutionalize conventional mining.
Regulation	ASM miners are less likely to have established health, safety, and environmental (HSE) policies in place. Explosives, excavation, and mercury usage in gold ASM are frequently unregulated in terms of HSE.	Companies in the conventional mining sector are more likely to have established policies and processes in place for dealing with HSE issues. In comparison to ASM, HSE considerations for conventional mining are more actively controlled.
Range of commodities	Gold and a variety of “development minerals,” such as sand, gravel, and stone, are the primary focus of ASM.	Conventional mining covers a broader spectrum of mineral and metal-based products.
Employment	The number of persons working in ASM outnumbers those working in LSM. Because the formal obstacles to entry for ASM labour prospects are lower, the industry attracts a higher share of women and younger people.	Large-scale conventional mining employs a large number of individuals in specialized positions in a variety of trades and professions.
Availability of technology	ASM will frequently work on smaller areas, extracting materials closer to the surface. The volume of ASM production is claimed to outnumber the conventional mining sector on a worldwide scale.	Given the availability of technology and the size of concession areas granted, large-scale conventional mining can extract and process greater quantities of ore.
Development process	ASM’s development is less organized, and it can be a seasonal (or supplemental) economic activity.	The project development process of conventional mining is more defined and “stage-gated."
Lead time	ASM miners can deploy machinery and personnel more quickly. They may typically adapt more quickly to changing market conditions, such as rising commodity prices and “new findings".	Conventional mining on the other hand operates on long lead times due to the amount of money required and the approval process.
Tenure	ASM operates without a legal or official title or permits in most cases.	Conventional mining processes are more frequently tied by legal instruments that define where mining can take place, and how resources are to be mined and managed.

- The collective effects of both sectors can be meaningful. Broadscale ASM has had destructive environmental consequences in certain parts of the world. Similarly, the cumulative influences of conventional mining have been substantial where large mines are gathered in proximity.
- Approval and acceptance of land and resources might be based on formally recognized processes as well as customary or non-formal ways.
- Both sectors generate local jobs and economic multipliers, albeit to varying degrees in different locations.
- With rising metals demand and pricing, both sectors are interested in a growing number of commodities.

Tanzania, like other African countries, is known for top-down approaches when it comes to legislation and policy formulation

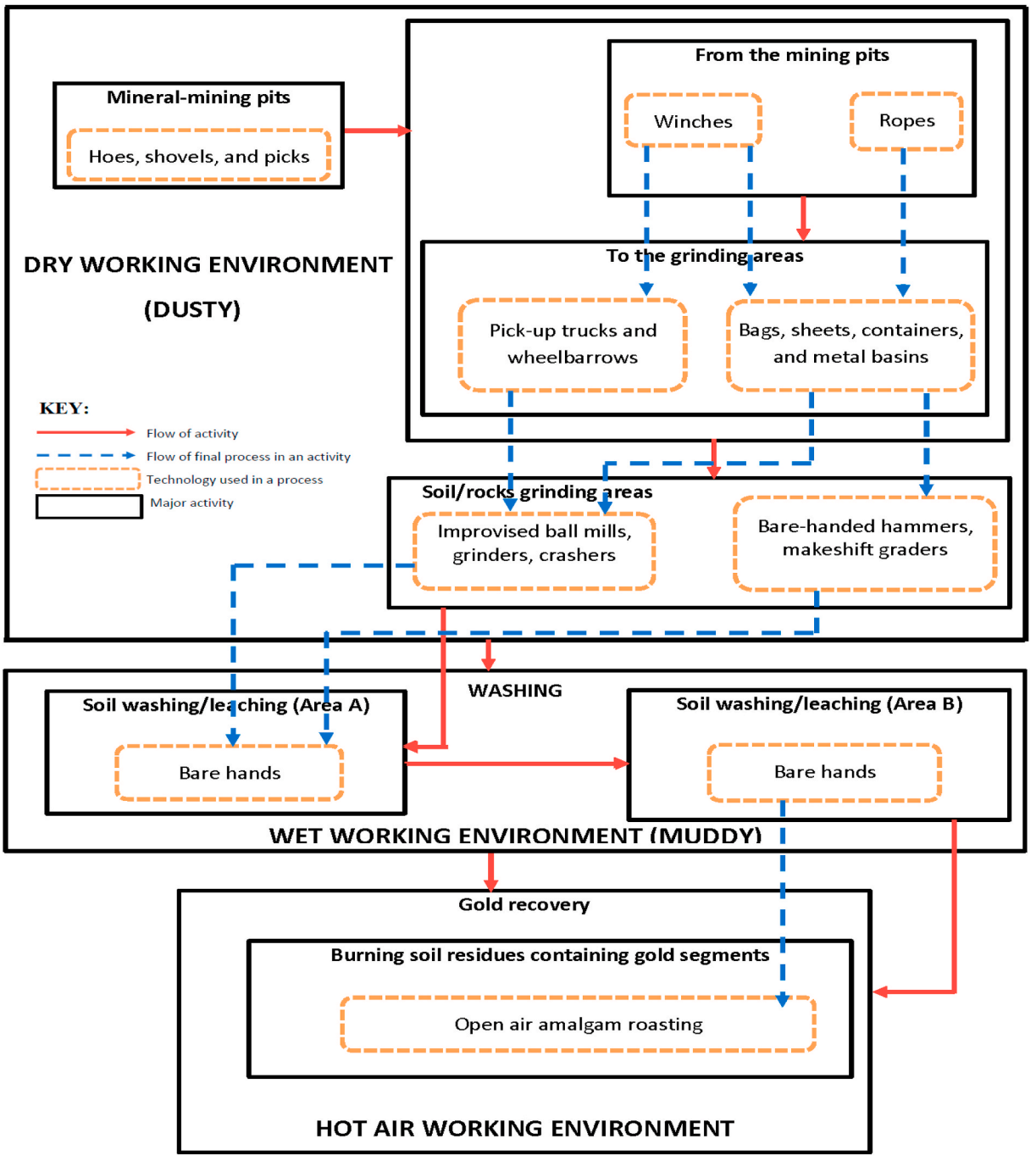

Fig. 1. Authors' interpretation of the working environment at one of the ASMs in Tanzania as a result of a field research visit in 2020.

relating to natural resources management [43–45]. In Tanzania, the National Environmental Management Council (NEMC) and other regulatory bodies work extensively to control environmental contaminants and to establish rules and guidelines to regulate the release of heavy metals and other toxic substances into the environment. However, there is no institutional framework that clearly outlines the duties of each of these regulatory bodies and this provides room for institutional conflicts. Besides, Tanzania solely relies on international standards as far as regulating environmental contaminants, especially heavy metals are concerned. However, environmental standards established based on locally collected data and considering site specificity would be more meaningful and easier to execute.

It is no secret that the existing policies and guidelines that regulate the mining sector in Tanzania are highly fragmented and detached from the on-ground realities of the ASM communities [8,46,47]. Some scholars have pointed out that the mining regulatory frameworks of Tanzania do little to touch on sustainable development issues such as environmental and human health concerns, in particular, risks associated with heavy metal pollution in the ASM subsector [48–51]. In addition, the regulations, laws, and policies that guide long-term supervision, recovery activities, and mining activities in Tanzania are either not well documented or the documentation is not coherent.

Also, the working environment and style in the ASM as presented in Fig. 1 point to the need to re-analyse policies, laws, guidelines, and regulations in the Tanzanian mining sector to effectively change things on the ground. This should consider the role of citizen participation in mining policymaking. Unfortunately, the classic top-down model displayed in Fig. 2 where policies are made at a ministry level or the ministry department's level is not working for the communities and the government as well. Therefore, this study suggests an integrated approach, where the government may initiate the policymaking process but seek to incorporate scientific findings and largely involve community members, especially the ASM miners.

Fig. 2 shows that the planning and formulation of sector policies in Tanzania is the responsibility of the relevant sector ministries [52]. These Ministries are responsible for developing or revising sector policies, as well as monitoring their implementation and consequences. To review the performance of respective sectors and establish the framework and policy declarations, ministries may form task forces or committees under the direction of the policy and planning divisions. Technical teams are often made up of ministry personnel as well as personnel from other implementation organs such as local government agencies, research and training institutions, non-governmental organizations (NGOs), and, on rare occasions, the private sector. Technical teams are designed to bridge the gap between policymakers and implementers to ensure that policies are implemented smoothly. The technical teams seek input from relevant stakeholders such as ministries, institutions, the commercial sector, and NGOs and then arrange workshops to validate their positions on specific problems. For editing, finalization, and production of a final copy to be delivered to the government for approval, a series of workshops are scheduled. As the necessity arises, a department within a sector ministry may establish a sub-sector policy within the scope of a sector policy on a specific topic [52].

After being considered at the ministerial level, sector and sub-sector policies are forwarded to the cabinet secretariat, where they are thoroughly discussed before being forwarded to the Inter-Ministerial Technical Committee (IMTC), which is made up of permanent secretaries from all government ministries. The policy paper is submitted to the cabinet based on the IMTC's proposal [52].

The cabinet debates the policy paper given by the sector ministry and adopts a consensus position that serves as a roadmap for execution. After the cabinet approves a policy, it is sent to parliament for information; however, the parliament may remark on the policy and advise the government if it needs to be improved. The cabinet may also be requested by the sector ministry that the proposed policy violates current laws or that a statute is required to put the policy into effect. The Cabinet may then opt to send the

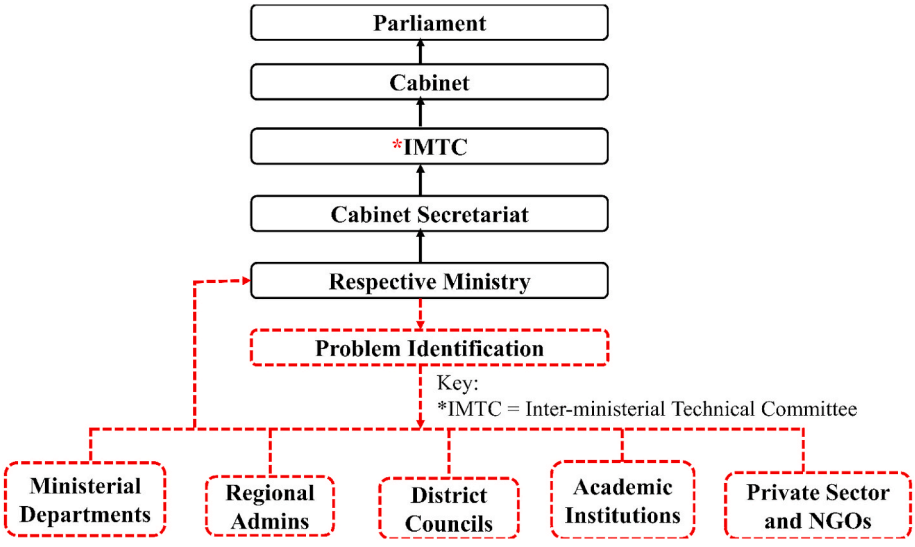

Fig. 2. Framework of the policymaking process in Tanzania as modified by Mattee [52]. Black solid lines and boxes indicate the original flipped top-down and the red dashed lines and boxes indicate revisions by Mattee [52]. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

decision to the parliament for enactment or amendment of the current law(s). The government's bill is next debated in the parliament, and it might be approved or rejected.

This highly linear and specialized process serves to enable the government to put in place desirable policies and acts. However, this process highly marginalizes the communities and the ASM miners who are the direct beneficiaries and victims of mining activities. The ASM miners, through their associations, need to start the policy formulation process. This will require extensive educational campaigns by mining companies, NGOs, academics, public health professionals, and researchers to sensitize small-scale mining communities on the role of a cleaner environment and working conditions.

2. Methodology

This work used content analysis of several official documents. A total of 27 documents related to the mineral and mining sector of Tanzania have been analyzed. These documents include six (6) policies, 12 acts/laws, 5 regulations, and 4 strategies. Also, official documents from other countries such as Ghana, Namibia, and Australia [53–57] were reviewed. Journal articles, reports, books, thesis, and dissertations were also referred to. These documents were filtered from google search engines from different platforms such as google scholar and ResearchGate. The study has also been conducted from the point of view of how policy settings play a significant role in the governance of the ASM subsector in Tanzania. In this regard, content analysis review techniques were used for Tanzanian legislation and policies as well as best practices from other places to aggregate facts. Hence, the paper is limited to secondary sources of evidence.

This paper systematically reviewed Tanzania's legal framework documents related to the mineral and mining sector. An online search of acts, regulations, and guidelines relevant to the mineral and mining sector was performed on the Tanzania government's official websites. Keywords used for the search were: Policy or policies, acts or acts, law or laws, guidelines, and regulations all combined with mining or mineral and Tanzania. Table 2 shows a total of 27 documents retrieved from the searched databases, of which six (6) were policies, twelve (12) were acts/laws, five (5) were regulations, and four (4) of them were strategies.

In this study, descriptive statistics including frequency tables and percentages were used to analyse the selected Tanzania legal framework documents.

3. Results and discussion

3.1. ASM policymaking in Tanzania – international influence?

In the present study, six policy documents as described in Table 3 were analyzed to identify the gaps between policies and realities on the ground in the ASM environments in Tanzania. Among many policies in Tanzania, the five selected policies have a close link between the mining industry, the environment as well as public and occupational health. It was observed that 80% of the policy documents analyzed did not directly cover issues related to ASM. These policies lacked important aspects such as public health, occupational health, environmental pollution, public health education, awareness of mine wastes, technical support, and hazards related to excessive exposure to environmental pollutants. These realizations highlight the importance of establishing the national radiation background and doses, government commitments, and defining priorities for policy review. On the other hand, a practical strategy should involve the following aspects: 1) raising the awareness of the miners about matters relating to mining hazards, 2) establishing government programs to provide in-field technical support, 3) using information-based strategies to encourage sector-wide improvements, unionization, and community involvement, 4) encouraging the social organization of gold miners, 5) strengthening small-scale worker groups, micro-financial institutions to raise capital to support sustained improvements, and 6) offering effective enforcement measures.

The links the ASM subsector has with the development of social and economic sectors in Tanzania are intricately undeniable. The caveat in mineral policymaking in Tanzania is that issues related to the regulation and control of the adverse impacts of the ASM subsector are rarely addressed. Although the lack of local people participation can be blamed for poor ASM policymaking, there is a need and potential for ASM policies in Tanzania to strike a balance concerning the environmental, social, and economic impacts of the ASM subsector. In this case, we suggest a circular approach model to policymaking that would be a useful tool as shown in Fig. 3. If this cycle is followed all scientific findings, concepts and advice would be integrated into the formulated policies [64,65]. This will also allow for the integration of matters related to environmental pollution due to ASM activities. This is important because Tanzania's approach to mineral policymaking has been anchored in adopting the standards set up by international mining and mineral societies

Table 2
Types and number of Tanzania legal framework documents related to the mineral and mining sector.

Document Type	Frequency (*N*)	Percentage (%)
Policy	6	22.22
Acts/Laws	12	44.44
Regulations	5	18.52
Strategies	4	14.81
Total	27	100

Table 3
Summary of main policies influencing ASM in Tanzania.

Policy	Issues of ASM	Reference (s)	Remarks
1. The Mineral Policy of Tanzania (2009)	Support and development of ASM are addressed in this Policy. For example, the objective of Policy (f) in Section 5.6 states "*To promote and support the development of ASM to improve its contribution to the individual and national economy*". Also, the Policy states the need for the government to collaborate with stakeholders in the ASM sector to preserve the environment. Also, 'The *need for technical services to the ASM sector*' is emphasized in Section 7.3 of the Tanzanian Mineral Policy.	[58]	The Policy lacks some important aspects such as 1) environmental exposure 2) occupational exposure 3) mercury toxicity and 4) mercury exposure which are frequently reported in the ASM working environment. This policy needs to be revised and important aspects of ASM be included.
2. National Forest Policy (2008)	Section 1.1.2 informs that the mining sector is one of the main economic sectors in Tanzania. However, Sections 1.3.2 and 2.3 of the National Forest Policy named the mining sector among the rapidly expanding human economic activities that contribute to severe environmental degradation. Still, having pointed out mining as an important economic sector in Tanzania, it does not include the issues of the ASM subsector, which is rapidly growing in Tanzania and is frequently reported as contributing to environmental pollution and deforestation.	[59]	Because the ASM is a fast and rapidly growing subsector that has been frequently reported to contribute to deforestation, there is a need to revise this policy and include the issues of land degradation in the ASM environment which will help to safeguard the environment against unsafe mining practices by artisanal and small-scale miners. In addition, the forestry and mining sectors need to work together during policy development.
3. National Land Policy (1997)	Objective 2.2 of the National Land Policy recognizes that "*smallholders such as peasants and herdsmen who are the majority of the Tanzanian population have all the rights to land ownership.*" However, the Policy barely includes the fast-growing ASM subsector. Furthermore, there are general provisions on health effects resulting from animal keeping and cultivation on hazardous lands, preventing buildings on hazardous lands, and protection of risk groups such as children in hazardous areas.	[60]	The National Land Policy needs to be revised because the ASM has been reported to have conflicts with the neighboring communities on issues of land allocation, acquisition, and use. There is a need to have a clear definition of land ownership in the sphere of artisanal and small-scale mining. Therefore, issues of the ASM and mining, in general, should be included in this Policy.
4. National Occupational Health and Safety Policy (2009)	The National Occupational Health and Safety Policy statement ii-iv emphasizes the need for the government and all stakeholders "*to develop occupation safety and health standards, to ensure occupational health and safety compliances for the military installations, and to conduct awareness campaigns to gear the safety issues to the employers, workers and the community*". It does not address matters related to ASM.	[61]	The health and safety issues in the ASM subsector in Tanzania should be carefully addressed. This is because this sub-sector is operated by people with small capital investment, but who can significantly contribute to the national GDP. In some cases, the rural economy largely depends on this subsector. In such cases, it is mostly the women and youth who perform mining activities. Therefore, the Policy needs to be revised to include the issues of the ASM such as radioactive and trace elements exposure as well as occupational safety.
5. The National Health Policy (2017)	Objective XX of the National Health Policy puts it clear that there is a need for safety and supportable health at workplaces. Objective XXII further emphasizes the need for environmental pollution and climate change control. The Policy, however, does not directly address issues related to ASM.	[62]	Environmental pollution and climate change have been frequently reported in the ASM. These have contributed to human health problems in the ASM working environment and surrounding communities. This Policy needs to include the issues of public health risks and hazards such as radionuclides occurring in the ASM environment. Also, the National Health Insurance Fund (NHIF) may be introduced to small-scale miners to make them access health services easily.
6. The National Nuclear Technology Policy (2013)	The Policy explains the use and advantages of nuclear medicine. Also, the Policy generally addresses some issues related to the sources of radiation due to NORMs and their implications specifically focusing on uranium mining. However, the ASM subsector is not directly included.	[63]	This Policy could include the issues of NORMs resulting from the ASM environment. This is because the ASM subsector is expanding rapidly and health risk due to NORMs is frequently reported in the sector.

and organizations. However, this approach does not give the possibility of including the in-country scientific findings and hence balancing the social and economic benefits against environmental costs because international standards are developed based on missions that differ from the local settings. For instance, heavy metal standards are established based on the background of an area that is also largely influenced by the weather, climate, and geological characteristics of an area. The dependence on international standards in Tanzania has led to some conflicts because the standards used in the country's policies, laws, and regulations do not address the control effects of additional background or incremental levels of heavy metals. Therefore, it is important to develop Tanzanian mines and mineral policies considering local prevailing circumstances using the now available scientific evidence.

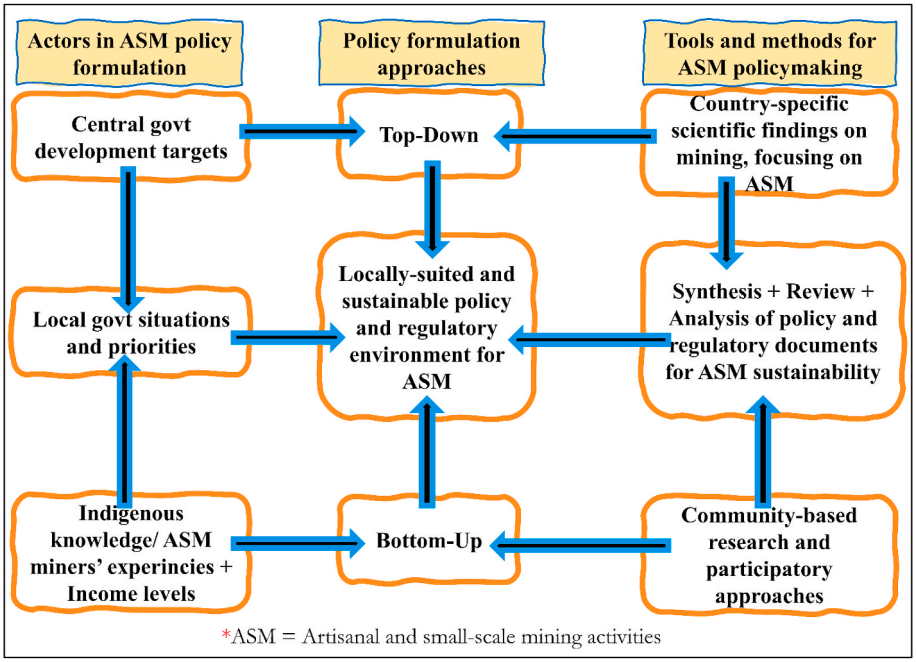

Fig. 3. Proposed integrated approach to policymaking in the ASM subsector.

3.2. Local scientific data and policymaking

Some of the mining and mineral policies that Tanzania has adopted or inherited from the colonial era, require that before commencing a mining project, a thorough environmental impact assessment should be conducted. However, the actual implementation of this important guideline is somewhat questionable. Since the mid-90s there have been studies undertaken in the mining areas of Tanzania to investigate the levels of trace elements, heavy metals, and organic pollutants. The present study argues that the findings in these papers need to be included as inputs in the policymaking process. It is not clear why such local scientific findings are usually never taken on board when developing policies and regulations in Tanzania. We hypothesize that this could also be linked to the poor analysis and documentation of data from previous studies, leading to a lack of meaningful and consistent environmental datasets. Without consistent information, it is also difficult to measure, quantify and establish the human health risk to workers in the ASM sector and surrounding communities, making it difficult for the Tanzanian government to make informed decisions about any environmental or public health-endangering relating to mining activities.

3.3. Tanzania's ASM sector and international regulations

The activities involved in long-term supervision, mining, processing, and recovery are subject to a diversity of national rules for the accountability of all parties involved and affected. Internationally, the perspective is that ASM pollutes the environment and the view is that ASM should somehow be transformed for it to be sustainable [24]. However, in this study, it is argued that ASM may not be an environmental problem if mineral and mining policies are grassroots-based, embracing local on-the-ground conditions. This study emphasizes that small-scale/artisanal miners and the government should work together to develop an ASM policy oriented to miners for the sustainability of the sector. The marginalized, and sometimes, criminalized miners – their voices – need to be heard in the formulated policies. The global/international "*umbrella*" policing for sustainable development e.g., 'Transforming our World' alone does not take into consideration the local environments [66].

In most developing countries of the Global South, Tanzania included, national economic growth policies usually give privilege to the multinational conventional mining companies [24]. The ASM is largely excluded, isolated, at risk, and regarded as enemies of environmental sustainability. However, it is important to note that, in some countries in the Global South, ASM far exceeds conventional mining concerning the size of the workforce, the amount of minerals produced, and the number of people/'*beneficiaries*' involved [67]. In Ghana, for example, ASM accounts for 30% of the total gold produced [68]. Therefore, this study proposes that Tanzania develops its regulatory framework for the ASM sector, a framework that considers the livelihoods of locals and the sustainability of the environment.

3.4. Status-quo legislation and amendments

There are more than 300 ASM sites in Tanzania including both licensed and informal ones [69]. Compared to other countries such

as Liberia and Ghana with around 787,500 and 1.1 million people working in the ASM sector respectively, the number of artisanal and small-scale miners in Tanzania is reportedly 1.5 million people [70]. According to the World Bank [70], the government launched a web-based application portal in 2015. Whereas from a total of 35 primary mining licenses (PMLs) in the year 1999, the licensing rose to an average of about 5500 PMLs per year between 2000 and 2017. Such estimation indicates that most people engaging in ASM operate informally despite registration initiatives taken by the government and are constrained by several challenges like low availability and access by miners to geological information, and insufficient demographic as well as other related information on ASM [70].

The United Republic of Tanzania (URT) has indicated its intention to formalize the ASM sector, although through state-led, top-down approaches [71]. Tanzania's efforts to formalize its ASM sector are driven by the country's desire to achieve the global Sustainable Development Goals (SDGs) and mitigate the negative environmental impacts caused by the mineral subsector. On the contrary, it has been shown that the formalized artisanal miners pollute as much as the informal ones [72]. Thus, the formalized miners are unable to fulfil their commitments to pay taxes, meet their legal obligations, or simply to work in a more environmentally friendly manner without technical and legal support. The majority of legal licenses are out-of-date, and miners employ mercury and cyanide to dump tailings into nearby drainage systems. Hence, formalization only makes pollution official if there is no support or enforcement.

Due to the 'colonial' approaches that Tanzania is currently planning to use to reform its mining and mineral sector, this document predicts the failure of the planned reform rooted in the exclusion of the voices of the local community in the legislative process. Since the Government of Tanzania has aimed to make ASM a national economy sector, the legislation-making process must be participatory and highly inclusive (gender, small-scale minors, microcredit companies, traditional health professionals, village communities, and local governance structures). According to a recent study by Veiga and Fadina [73], co-existing artisanal miners and the holders of mineral titles (such as conventional mining firms) are successfully getting popular and have been observed in practice. The coexistence model, which assumes that the miners mine while the processors' process, was developed as a modest change to the approach to strengthen the connection between the miners and ore-processing businesses. To make the process participatory and avoid conflicts among different stakeholders, it was suggested that the government grant mineral titles to conventional businesses rather than to artisanal miners, who are typically the ones who discover the mineral reserves.

In Fig. 1, the bottom-up approach to legislative making can reduce legislation failures and the exacerbation of rural poverty. Efforts such as granting mining rights, licensing ASM, and apportioning concession quotas to make ASM taxable and a contributor to the state coffers should be done carefully and with measurable participation. In general, policies are offered as a means of addressing and resolving problems that have been identified. The goal is to identify the problem's root causes and solve them in the policy formulation process. Individuals, communities, organizations, public or private institutions, and other interest groups are all potential sources of ideas. These concepts are then developed into policies.

It is anticipated that Tanzania's policy-making process should be designed to be bottom-up, participatory, and consultative to ensure that people's opinions are taken into account, in which the procedure begins with the identification of an issue that must be resolved. After identifying an issue, follow the identification of the stakeholders who are most affected by the problem, as well as the roles those different stakeholders play in addressing the problem and finding a solution. The process is open to all major stakeholders, including the government and its institutions, as well as key actors in Regions, Local Government Authorities, and local communities. Stakeholder participation is encouraged from the beginning of the process to ensure that all stakeholders' views are discussed and supported. Interviews and interaction with diverse persons (individuals or groups), workshops, and round table meetings are some of the ways that can be used to encourage participation. The mainstream media may also be heavily involved, as seen by special articles and features in newspapers, as well as discussions on radio and television. To guarantee that policy papers are thorough, relevant, and address stakeholders' concerns, a participatory method is proposed. Despite the benefits of the bottom-up approach, it may also pose challenges that may negatively impact the overall ASM policy-making decision. For example, depending on local conditions, especially community size and heterogeneity of mining stakeholders, the process of making consensus for building the criteria for effective policymaking can be expensive and time-consuming [74].

3.5. *Scientific findings and community participation*

Scientific research findings are very important in policy development and improvement [64,65]. New scientific outcomes play a significant role in nourishing existing policies and in forming new ones because they target emerging matters of policy relevance. Science needs to guide policymaking, giving methodological assistance to policymakers to smoothen the course of action. Likewise, scientific guidance may be required on an ad-hoc basis. The updated response may be given once wanted to help improve and preserve the policies. Other main disputes in the monitoring process for public involvement involve three main factors, namely, the endorsement of rules for overall applicability, permitting certain facilities, and improvement of post-closure procedures for facility recovery and continuing supervision. Regarding the endorsement of rules for general applicability, the existing regulatory configuration requires that members of the community who are concerned about metal mining and processing in Tanzania respond to policymaking through their grassroots organizations [35–37,41,75]. The ministry responsible for mining and minerals could offer an online-based mechanism for information gathering and organization that would aid the current and future national-level dialogues relevant to mining. The COVID-19 global pandemic has taught us the usefulness of online platforms. The government of Tanzania needs to take advantage of these platforms that were strengthened during the pandemic. Currently, the ministry [in theory] has a strong approach to community involvement in licensing metal processing facilities. The guidelines require that the ministry do environmental assessments before a mining license is awarded and that community gatherings or hearings should be held in the neighbourhood of the planned facility [34,37].

3.6. ASM: environmental and human health dimensions

Since the ASM industry is a rapidly growing sector in Tanzania, it is important to focus on the safety and health of the environment and the surrounding communities. The ASM is a culprit when it comes to environmental and human health risks [11–15]. Environmental researchers, governments in the Global South, and conventional mining companies all blame the ASM for the deterioration of the environment and the potential for human health concerns. Unfortunately, the voices of the '*ASMers*' (the blamed ones) are usually never heard. The story of pollution and risk is usually one-sided.

The human health risk is usually considered biological, chemical, psychosocial, biomechanical, and physical. Researchers have pointed out that the risks of specific significance to susceptible subjects, for example, children and women, are of greater importance to address. However, several of such risks could be attributed to factors, for example, the absence of miner training on health threats; inadequate access to protective gears; and imperfect technical awareness due to inadequate practical training, little knowledge about heavy metals pollution, or low literacy rates [42].

The ILO informs that approximately one million children aged between five and seven years are involved in ASM activities around the world [27]. However, in the 27 official legal framework documents reviewed, the ASM sector, which is rapidly growing in Tanzania is not properly regulated. Indisputably, for Tanzania's government Acts, it was found that the seven (7) documents reviewed were about mining in general representing 58.33%.

This observation shows that existing Acts and regulations would do little in solving or at least mitigating the problems facing the ASM in Tanzania, making it difficult to achieve the SDGs and the Tanzania five years development plan 2021/22–2025/26 [76]. It was found that five (5) Government Acts representing 41.67% focussed on the ASM sector even though there existed some gaps. The gaps in

Table 4
Some gaps in Tanzania's government Acts on the ASM subsector.

Act	Issues of ASM	Reference (s)	Remarks
1. The Mining Act 2010	CAP. 328 of this Act defines the ASM in terms of capital investment. And Part III explains the Board that advises the Minister on issues relating to mining. The Board includes one member from the ASM. The Act also gives the Minister power to regulate various mining issues. For example, Part X CAP. 188, Section 108 (5) states, *"The Minister shall make special regulations to ensure public safety and regulate mining, processing, hauling, transporting, conveying, marketing and disposition of radioactive minerals"*. However, this statement is inherently concerned with conventional mining, especially dealing with radioactive metals such as uranium.	[77]	Although the Act explains well the procedures of dealing with radioactive materials, it resides more with the conventional mining subsector, which deals with radioactive ores such as uranium. But the issues of radiation exposure in the ASM must be given special attention due to the nature of the working environment. Therefore, future revisions of this Act and its regulations should include matters of public health in the ASM environment.
2. Public Health Act (2009)	Overall, the Public Health Act of Tanzania (2009) does not address issues related to ASM. However, there is a general provision indicating hazardous and healthcare waste management.	[78]	The public health issues in the ASM and surrounding communities have recently become a global agenda. This could be due to the nature of the working environment. Therefore, health issues in the ASM subsector in Tanzania must be given special attention to laws and regulations. Hence, issues related to the welfare of ASM mining should be included in the next revisions. This might help to minimize the health risk in the subsector.
3. The National Wealth and Resources (permanent sovereignty) Act (2017)	The National Wealth and Resources (permanent sovereignty) Act does not address the issues in the ASM sub-sectors. However, it puts clear the ownership of the natural resources. Part II section 5 (1) of this act explains clearly that *"the natural wealth and resources shall be inalienable in any manner whatsoever and shall always remain the property of the people of the United Republic"*.	[79]	Mineral resources in Tanzania contribute more to the wealth of the nation and individuals. Recently the government of Tanzania has worked to improve the ASM subsector due to its contribution to the nation's GDP and poverty lessening to the poor communities of Tanzanians. For these and other reasons, we suggest the inclusion of issues of the ASM in this Act.
4. The Environmental Management Act (2004)	The Environmental Management Act of Tanzania does not touch on issues related to ASM. However, the Act emphasizes the issues of safety in the working environment. For example, section 6 part (h) reads "*To have the plan to ensure the health and safety of the workers and neighboring communities"*	[80]	The ASM subsector in Tanzania has been frequently reported to contribute greatly to environmental pollution. Studies have evidenced that mining wastes from the ASM pollute water, air, and soil. Because the ASM is a fast-growing subsector, there is a need of having a special inclusion of the ASM-related issues in this Act.
5. The Land Act (2009) with its revision of 2019	The Land Act does not say anything about the ASM. However, it covers problems regarding hazardous land.	[81]	Mining especially the ASM subsector has been frequently reported to cause hazards to the environment. Therefore, future revision should include matters related to mining including land ownership and utilization which are often leading to conflicts among miners and other citizens.

Tanzania's Government Acts on the ASM subsector are summarized in Table 4. It is seen from Table 4, most of the acts analyzed were found to not directly cover ASM issues. Therefore, information on environmental monitoring, assessment, safety, hazards as well as working environment such as good ventilation in mining pits, environmental pollution, public health education and knowledge on mining waste management, offering technical support to miners, and access to protective gears are missing.

3.7. ASM or large-scale (conventional) companies?

The answer to the question posed above is not easy to arrive at. It is debatable whether, as a country, which mining sector between the ASM realm, and conventional mining is more sustainable. Conventional mining operations cause just as much destruction as artisanal or illegal operations, but to a lesser extent. On the other hand, the ASM subsector is a vital basis for economic support, particularly in rural communities [42]. Even though the Tanzania Mineral Policy of 2009 powerfully stresses the necessity to set out plans for justifying artisanal and small-scale mining into well-thought-out and resourceful procedures to safeguard profitable employment and poverty lessening, it is still questionable whether the stipulated goals can be achieved. Whereas the Tanzania Government has made strides to create an ASM unit in the organization structure of the Ministry of Minerals, there has been a shortage of participatory legal and policy frameworks to maintain and assist the sustainability of the ASM sector in Tanzania. The provisions of the country's Mining Act of 1998 and the Land Act of 1999 state that all land in Tanzania is formally owned by the Government and that any transfer practice must adhere to the laws of Tanzania. This poses the question of whether communities have the right to land and gives precedence to the Government to allocate the land to whatever entity can afford the cost [50]. We argue in this paper that this is the same colonial mentality prohibiting the colonized from land, infrastructure, and property ownership.

One consequence of this has been to aggravate fissures between the large-scale and small-scale mining sectors, causing conflict over land and other fundamental livelihood resources. Therefore, the necessity has arisen to formalize the ASM sector, including organizing and registering unregulated mining and introducing ASM into the formal economy. In addition, while conventional mining and ASM are the two subsectors covered in the policy, the artisanal and small-scale mining subsector is omitted in most cases. In light of this, even if the sector's policy setting does not adequately address the requirements of all players in the sector, there are some opportunities that Tanzania can exploit to ensure that the sector becomes fair, sustainable, and profitable for all players.

3.8. Mining policies: lessons from other sub-Saharan African countries

Similar to Tanzania, most of the sub-Saharan countries are also reliant on mineral resources [5,82]. The governments in sub-Saharan Africa generate and collect gold and gemstones with an estimated value of USD 1 billion annually. Additionally, the value of gold produced through small-scale mining is currently at US$200 million in China, USD 180 million in Bolivia and Brazil, USD 140 million in Indonesia, and USD 250 million in Peru [7]. However, only a small number of these nations where ASM is operated have passed or are currently enforcing explicit legislation to limit environmental pollution while maximizing profit.

Although most of these nations have revealed unsatisfactory outcomes concerning the supportable use of resources, and experience in other natural resource-rich nations, Botswana has shown that the mining sector can lead to sustainable socio-economic development. According to Lifuliro, Zilihona [83], some of the significant features underlying effective experiences in any investment take into account active policy frameworks and implementation procedures. In Botswana, for example, the mining policy has been branded by extraordinarily determined goals, intelligible design, and an effective implementation scheme for small-scale and artisanal miners. Whereas this is superior know-how with respect to such nations, the circumstances are different in Tanzania, where the small-scale mining sector has been linked to aggravations in environmental and public health status [1,12–15,42].

In Mozambique, as the size of the extractive industry extended, the nation has been involved in the solidification of the legal structures and monetary systems for the mining sector by increasing transparency in procedures and reporting [84]. For example, in 2009, Mozambique applied to the Extractive Production Transparency Initiative and was recognized to be completely compliant with the Extractive Industries Transparency Initiative (EITI) guidelines in 2012. Mozambique also recognized the Global Partnership for Social Accountability in 2012, which intended to expand development outcomes by supporting improved legal resident involvement and response [85]. As a result, Mozambique has been one of the fastest developing economies in sub-Saharan Africa over the last 25 years, with an average yearly actual Gross Domestic Product (GDP) growth of 7.4% [28]. This solid performance was supported by the determined application of credible macroeconomic guidelines and structural reforms, a promising external environment, donor funding, and, in recent years, the discovery and utilization of natural resources. In this concern, Mozambique has been carrying out well on governance with upgrading in crucial areas such as government efficiency, regulatory excellence, and the rule of law [28]. It is evident that community participation, the rule of law, human rights, transparency, and democracy are intricately interconnected with sustainable development and efficient utilization of mineral resources.

For Namibia, the country's constitution requires that all natural resources belong to the government. The Namibian Mineral Searching and Mining Act of 1992 offers that all rights and control over natural resources lie with the government [86]. The Namibian government has established its mineral rule to guarantee the growth of the mining sector. The policy aims to equalize the interest of foreign and native investments in mining. According to government policy, the government tries to find opportunities for Namibians to profit from their nation's mineral resources and improve their socio-economic livelihoods [86].

It is commonly suggested that Namibia's mining policy article is extraordinarily effective in its intent as it permits better government involvement in mining production to protect straight profit from mineral production for the benefit of the Namibians. As a result, the performance of the Namibian mining division has been remarkable, recording a GDP share of 12% from mining by 2012 [28]. The condition in other nations such as Zambia, Ghana, and Botswana where the sector has been flourishing, local content

guidelines have been established and executed to capture more profits from the sector [28,53]. In line with the possible profits accumulated by the local people, it has been essential for the nations rich in mineral assets to embrace local content requirements in their policies and laws.

The rapid expansion of the gold mining industry in Ghana has been largely attributed to the Minerals and Mining Law that was passed in 1986 and the Minerals Commission that was established to coordinate policies regarding the country's mineral resources and to govern their exploitation [7]. Contrary to this; despite the fact that Brazil recognizes the importance of efficient licensing and regulatory systems, "the vast majority of mining operations are unlicensed and uncontrolled and the environmental and social repercussions are substantial". On the other hand, the licensing of small-scale sand and gravel extraction operations in the Philippines has given local governments a new source of income, particularly in the form of royalty fees [7].

Over the past twenty years, ASM has increased significantly in many developed countries. As a result of the adoption of tools intended to stop illegitimate ASM organizations and activities in these countries is a global concern. Many populations in South America that depend primarily on different types of fish as their major food supply are burdened by pollution and deterioration of water resources in places like French Guiana, Surinam, Guyana, and Brazil [87]. However, the governments of these nations are unable to enact laws and policies that are both effective and in line with developed-world environmental norms and those that would eliminate current pollution. The majority of governments in developed and Third World nations adopt ASM policies and regulations despite the fact that the vast majority of them lack the information necessary to do so. It is safe to argue that most governments lack information on the locations of numerous relevant ASM activities, the materials each is obtaining, how much of each is being extracted, the types of equipment being used at the locations, and the demographics of those participating [88].

In cases where mining sites are already covered by other mining rights, such as prospecting permits and exploration licenses associated with large mining projects, legalizing small-scale mining operations looks to be the most difficult. The same issue also arises when large mining operations are granted prospecting or exploratory permits over regions where small-scale mining operations are already in place. The Philippines made an attempt to solve this issue by passing specific legislation that limited gold sluicing and panning inside active mining claims. In a sense, the law permits dual licensing for the same region, but it hasn't worked because concession holders have not given their assent. However, there are further methods that can be used to make ASM within existing mining concessions legal [89]. Attributing agreements, operating contracts, and contract mining fall under this category. Most of these legislations are usually initiated by the mining organizations or are carried out with the help of authorities, like in the instance of Papua New Guinea, where the government has actually created standard tributing contracts through the Department of Mines. According to reports, Mongolian law has also adopted this "privatized licensing scheme" for ASM. In Mongolia, license holders are encouraged to contract out (to small-scale miners) areas of the deposit that might not be economically viable to exploit using conventional (large-scale) industrial techniques. This procedure effectively results in the surrender of tiny deposits that are unimportant to the holders of licenses. The government should then retake control of these sites and make them available for use by small-scale miners [87].

In contrast, for Tanzania, the impact of mining on the Gross Domestic Product (GDP) is still small when likened to Botswana and Namibia. The contribution of the mining sector to GDP accounted for 3.7% in 2014, 4.0% in 2015, and 4.8% in 2016 [90,91]. For Tanzania, there is therefore a need to improve the situation through the active participation of citizens for the improvement of the ASM sector and the reduction of poverty. Incidentally, Botswana and Namibia are viewed as role models for sub-Saharan African nations as they have stretched their economic and social development by consolidating their mining and mineral sectors [92].

4. Conclusions

Tanzania has an opportunity to acquire constructive ideas from other prosperous mining nations discussed above and to restructure its mining and mineral policy framework to be more inclusive and grass-roots-based. This paper has laid down some groundwork that the government and grassroots societies can build on. Prosperous mining nations have one thing in common: they all have a strong policy and legislation framework that facilitated the opening up for resource-centered development and inclusive growth. Good governance structures that are inclusive play a significant role in promoting development connections with the artisanal and small-scale mining sub-sector.

To this end, this paper proposes a pathway in which the government plays an enabling role, an environment conducive to a progressive path to sustainable mineral resource-based development. The mining and mineral sector as a whole should not be left in the hands of market forces. The extractive industry has socio-economic connectedness beyond the minerals' market values. If left to market forces, some aspects of societal values linked to rural livelihoods may be lost. Tanzania can also learn that when well-managed, the small-scale mining subsector can generate employment, encourage the transmission of knowledge and technologies, and create treasured foreign exchange earnings. This article also has the perspective that the achievement or failure of any development and growth based on resources is country-specific. In some situations, in the Global South, one-size-fits-all approaches will not work. The cultures and contexts of the local community are as important as the scientific evidence of mining-related pollution.

This document presents challenges and opportunities for the situation of mineral and mining policy in Tanzania. The paper has largely focused on the artisanal and small-scale mining subsectors. The authors have attempted to showcase the progress Tanzania has made in its extractive industry and how non-holistic mineral policymaking can slow the country's progress toward achieving the SDGs. There has been a measurable transformation in the mining sector but, overall, the ASM subsector has largely been side-lined. The neglect of such a large subsector (by the number of people directly or indirectly benefitting from the ASM has adverse effects on the practicalities of the mining and mineral policy by small-scale miners and the surrounding rural dwellers. This paper further insists that for any policy related to ASM to be fruitful, it should be made by those directly affected by the activities of the subsector. Marginalizing

the small-scale miners and the rural poor majority in ASM policymaking will only lead to the marginalization of human and environmental health by those practicing the ASM.

Author contribution statement

Mwemezi Rwiza and Erasto Focus: Conceived and designed the experiments; Wrote the paper.
Jonas Bayuo, Jerry T. Mosses, and Theresia J. Lyasenga: Performed the experiments; Wrote the paper.
Joseph M. Kimaro and Janeth Marwa: Analyzed and interpreted the data; Wrote the paper.
Matthias Kleinke, Erasto Focus, and Mwemezi Rwiza: Contributed reagents, materials, and analysis tools; Wrote the paper.

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Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interest's statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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