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RESEARCH ARTICLE



The place of Indigenous knowledge system in mapping and extraction of minerals in the lake Zone of Tanzania

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ABSTRACT

The paper assesses the place of Indigenous Knowledge System (IKS) in mapping and extraction of minerals in Tanzania. It assumes that the IKS has been a base for identification and extraction of minerals, but very little is known as per current development of science and technology. Data for this paper was collected from artisanal and small-scale gold miners through mixed methods of data collection and analysis. The paper shows that most of the existing artisanal and small-scale fields were first identified by local people in their day-to-day routines and through the use of their IKS. In relation to extraction, IKS is used by both modern large-scale miners and artisanal miners. Because of cultural diversity in the mining centres, there is a likelihood of creating a unique culture of the mining community that will abide by, and share the mining traditions, taboos and norms to other broader, cross-cultural generations instead of inheriting from one generation to the other of the similar ethnic group. It is recommended that ways be found to harmonise IKS with modern mining knowledge systems to enhance growth in the mining sector.

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Indigenous; traditional; knowledge system; exploration; extraction; Tanzania

Introduction

Mining sector is among the fast-growing sectors in Tanzania. Its growth rate is about 10.2, and its contribution to GDP has increased from about 3.3% (Kabwe, 2012) to 4.7% in 2019 (Wizara ya Madini, 2020). The mining sector has been instrumental in the attraction of foreign direct investment (FDI) and in the country's efforts to revitalize and reform the economy since the mid-1990s. It has greatly contributed to foreign exchange earnings and in promoting Tanzania's export economy. For instance, whereas the value of mineral exports was slightly over US\$3 million in 1998, it had, by 2019, rose to \$2,326.7 (Magai & Márquez-Velázquez, 2011; Wizara ya Madini, 2020). Revenues in royalties from the mining sector have equally increased from 2.79 billion shillings in 2000 to 247.19 billion in 2019, while revenues from taxes increased from 18.5 billion in 2000 to 552.8 billion shillings in 2018 (Bank of Tanzania, 2018; Tanzania Minerals Audit Agency, 2011, 2012, 2016; Tanzania Extractive Industries Transparency Initiative [TEITI], 2018, 2020a, 2020b). This has made Tanzania rank among the top five

producers of gold in Africa even though the sector's contribution to employment remains at 1% of the total formal jobs in Tanzania (Tanzania Minerals Audit Agency, 2016). Aside from economic contribution, the mining sector has also been at the centre of electoral and government politics in the past 20 years with resource nationalist policies taking centre stage in government and popular debates and in government–investor relations (Poncian, 2019, 2023).

It should be noted that natural resources are not ubiquitous; their distribution varies over space. Some of these resources can replenish while others cannot. The African continent in general, and Tanzania in particular, is rich in natural resources such as forests, wetlands, wildlife, minerals, fisheries, and many others. However, the inventory of these resources has not been adequately done; thus, making it harder to know the real resource wealth base. Poor geological data owing greatly to Africa's technological handicaps has been shown to be the main factor for why Africa's full natural resource wealth potential remains less known (African Union, 2009; Economic Commission for Africa, 2011). Because of limited information about resource potential, most of these resources are at risk and some have been depleted due to limited management measures. Given Africa's limited technological capacity, does it not suffice to ask what role Indigenous Knowledge Systems (IKS) can play in mapping, extraction and management of mineral resources?

In the communities where the resources have been maintained for ages, the understanding of the ethos employed in the management and exploitation of resources is imperative. Traditional knowledge is a local and area specific way of understanding, locating, managing, and harvesting natural resources (Ellen et al., 2000). This is because different communities have different values, traditions, and customs. The lived and maintained values, traditions, customs and practices over time produce what is called the indigenous knowledge systems. IKS acts as a transforming agent. It can therefore be produced, reproduced, discovered and lost. It is more binding to the community than any knowledge. Although it may focus on specific issues and be coherent in rituals, and other symbolic constructs, its distribution is always fragmentary. It does not exist in totality in any one place or individuals (Moshy, 2006). It is also evident that much of the western science and technology emanated from the traditional European folk knowledge (Ellen et al., 2000). Traditional Environmental Knowledge System (TEKS) was synthesised and used as common wisdom and practice and later through research and justified.

Natural resources have for centuries been an important part of people's economy. Traditional communities derive both their social, cultural and spiritual identity from the land. Traditional use of natural resources was based on traditional values. Africa has always maintained a certain formidable power that guards the institutions and knowledge system, thereby maintaining some level of self-reliance (World Bank, 2004). It is also evident that for quite sometimes the resources were jeopardised due to interference of resource management approaches (Moshy, 2006). The fact that nearly half of IKS relate to natural resources indicates that spirituality has a strong influence in their management. One of the most interesting institutions derived from TEKS of practices is the establishment of sacred natural sites (World Bank, 2004). Taboos and traditional management codes commonly restrict access to these sites to particular activities and members of the community. These have contributed much in restoring and preserving water and forest resources in most communities of Africa and beyond (Ayaa & Waswa, 2016; Pelletier et al., 2019).

Sacred natural sites also contribute to forming an ethnic identity and play a key role in local communities' culture and lifestyles. This is because some community members receive their names through such sacred areas and some boast to originate or pass through such rites. For example, any Maasai will boast of undergoing *emuratta* (circumcision which is a rite) to become the *Moran*, a warrior which is a new age set in Maasai community (Haulle, 2014).

African traditional knowledge is labelled variously and misconceived in international discussion and in modern studies. It is considered to be static, low value-added and prior art. Yet very few strive to understand the fact that traditional knowledge has the power to improve livelihoods of the people and make them survive (Ayaa & Waswa, 2016). For instance, when tsunami stroke Thailand and Indonesia, the myth of Evil Spirits and learning the behaviour of buffalos made people escape the hazard and risky environment to safer zones and survived an hour before the catastrophic phenomenon (Haulle, 2007). The community won the Sasakawa Award in recognition of this traditional knowledge. While traditional knowledge rescued the indigenous people, modern technology only recorded the information about a minute before the hazard translated into disaster.

It is also important to note that globalisation brings about control of knowledge by new actors. Most of the communities have lost their control over their resources including minerals and knowledge. Knowledge, especially Modern Environmental Knowledge System (MEKS), is now a commodity (Kauppinen, 2013). Global knowledge system, technologies and capital combine to dominate the information revolution (Independent Commission on Population and Quality of Life [CPQL], 1996). Unfortunately, however, the local people and artisanal miners have limited access to such knowledge which has become the commodity; thus, making IKS a relevant and critical resource for mineral resource mapping and extraction by the artisanal miners.

This paper stresses that the sustainability of any resource depends on the community that uses and manages the said resource. It builds on an understanding that IKS can play a great role in natural resource inventory and management over space and time. Since IKS is embedded within the community, and it is born of the community, the paper advances an argument that IKS becomes a reliable resource for artisanal and large-scale miners to explore mineral-rich areas and subsequent discovery of minerals. A major question arising from this is how artisanal and large miners employ IKS to locate mineral deposits and what this says about the significance of IKS in modern economic systems. In exploring this question, we first provide an overview of theoretical and empirical debates on IKS in Africa's socio-economic development. We subsequently describe our paper's methodological approach and present and discuss the findings. We wind the paper up by considering the implications of our findings on IKS debate and broader usage in modern socio-economic and technological advances.

Indigenous knowledge and Africa's socio-economic development

Societies and communities across the world have developed their distinct knowledge systems akin not to modern scientific systems. Over time, societies have learned to master their environments through knowledge systems and practices handed down from generation to generation. An indigenous knowledge system (IKS) refers to a knowledge system rooted in indigenous people's ways of looking at and relating to the world, the

universe, and each other (Barnhardt & Kawagley, 2005). An IKS involves millennia old indigenous and/or traditional values, beliefs and practices associated with world-views that have survived major social upheavals and are finding relevance for today's generations as they did in the past (Barnhardt & Kawagley, 2008). IKS is arguably holistic and organic, non-dominating, non-manipulative and non-mechanical in the sense that it emphasises the social and people-centered and relational perspectives (Breidlid, 2009). It is a knowledge system whose learning across generations is characterised by oral transmission and learning through experience and repetitive practice (Breidlid, 2009).

Common as it may seem to suggest, it should be emphasised here that indigenous knowledge is not a uniform concept nor does it mean that indigenous knowledge systems are the same across different cultures and social systems. Instead, it is a diverse knowledge that is spread throughout different peoples in many layers and that is so much part of the clan, band, or community, or even individual, that it cannot be separated from the bearer to be codified into a definition (Onwu & Mosimege, 2004). IKS is an all-encompassing system that,

constitutes the core of community development processes such as agriculture; preservation of food; collection and storage of water; animal husbandry and ethnic veterinary medicine. It also forms the basis of indigenous interpretation of meteorological and climatic phenomena; orientation and navigation on land and sea as well as in management of natural resources. (Abah et al., 2015, p. 668)

This said, what is indigenous knowledge and how can it be harnessed to bring about socio-economic development, especially in areas such as mining which are considered to be technical and only requiring technocratic approaches? Indigenous knowledge refers to 'local or traditional knowledge that indigenous people have brought down with them from earlier times via the oral tradition' (Sen, 2005, p. 375). Indigenous knowledge comprises localised expertise on such matters as 'the ability to distinguish fertile and unfertile soils by color and scent, and complex fishing tactics designed to produce fish with the highest possible vitamin and mineral content' (Joranson, 2008, p. 64). What distinguishes indigenous knowledge from other kinds of knowledge is that indigenous knowledge is context and cultural specific, hence making it a powerful tool for local decision-making in agriculture, health, and natural resource management, among others (Maweu, 2011; Sen, 2005). IK is characteristically defined in 10 key aspects, namely, that it is:

local, and tied to a particular place and set of experiences; orally transmitted; the consequence of practical engagement in everyday life, and is constantly reinforced by experience and trial and error; empirical rather than theoretical knowledge; repetition is a defining characteristic of tradition; tradition is a fluid and transformative agent with no real end when applied to knowledge and negotiation is a central concept; characteristically shared to a much greater degree than other forms of knowledge; fragmentary distributed i.e. it does not exist in its totality in any one place or individual; functionally organised; and characteristically situated within broader cultural traditions. (Joranson, 2008, p. 67)

These 10 defining characteristics are what may make IK superior to modern, universalised systems of knowledge which do not take cultural and contextual factors into account. Because of its great potential, IK has been an area of focus in conservation, medical anthropology and agricultural scholarly studies since the 1990s (Adoukonou-Sagbadja

et al., 2006; Cheikhoussef et al., 2011; Critchley et al., 1994). It has been shown that integrating IK with modern scientific knowledge and methods results in ecologically sound, economically viable and highly productive land use system (Maweu, 2011; Pelletier et al., 2019; Schulz et al., 1994). IK has also been shown to have greater potential in detecting long-term ecological and climate changes and also useful in managing such changes, suggesting that modern approaches to understand long-term ecological and climate changes can richly benefit from integrative use of IK systems (Green & Raygorodetsky, 2010; Lauer & Aswani, 2010).

Coming back to IKS, several studies highlight the critical significance of IKS in socio-economic development especially in societies and communities where western-based knowledge systems have failed and in the context of several wicked challenges such as climate change and its consequences, environmental degradation and conservation, and rapid population increase that defy mainstream scientific knowledge systems (see, for instance, Barnhardt & Kawagley, 2005, 2008; Madonsela et al., 2024; Mbah et al., 2021; von der Porten et al., 2016). These and other challenges that Africa, and the world at large, face call for an integrated approach. Studies have long shown the dangers of relying on modernist, western and technocratic approaches to development in Africa mainly because these approaches fail to take into account contextual factors that shape Africa's development trajectory (Bush, 2007; Easterly, 2006; Klinghoffer, 1973; Mkandawire, 2005; Moore, 2001). Because of the inherent weaknesses of western models of development, there has recently emerged a body of knowledge that pushes for the decolonisation of the development discourse and knowledge production (Kalema, 2019; Ndlovu-Gatsheni, 2012; Tavernaro-Haidarian, 2019). It is within this context that IKS has increasingly gained scholarly and popular traction.

Africa's abject poverty has partly been blamed on Africa's and international community's neglect of indigenous knowledge, traditions, and local institutions (Figueiredo, 2001). This suggests that indigenous knowledge can play a significant role in poverty reduction and attainment of sustainable development. Although widely recognised as useful, IKS is yet to find full policy support and recognition in many African countries except in South Africa where some recognition was accorded to IK in the nation's curriculum in 2005 (Breidlid, 2009). It is rarely officially used. This is probably because some scholarly analyses still question its completeness, and its appropriateness as a tool in anti-discrimination and anti-repression (Horsthemke, 2008). Given this, we endeavored to contribute to the existing body of knowledge by examining the role of IKS in the mapping and extraction of minerals in Tanzania.

Methodology

The study was carried out in the lake zone of Tanzania. Lake Zone is famous for gold deposits and mining. The zone includes the regions of Shinyanga, Mwanza, Geita, Kagera, Simiyu, and Mara. Specifically, the study was carried out in the Geita region. The region was simple randomly selected from the zone which is rich in gold deposits. The region has both small- and large-scale mining companies and has antagonistic relations with local people. The study employed mixed methods design. The design was selected due to its strength of providing both quantitative and qualitative data (Creswell & Plano Clark, 2011). It has the power to bring in the lived experience and empirical evidence of the

phenomena. The study was carried out in three wards of Rwamgasa, Nyarugusu and Mgusu which are located in the vicinity of mining sites. These wards had very famous artisanal and small-scale mining sites in the Geita region and have attracted artisanal and small-scale mining since as far back as the 1980s (Lange, 2006, 2008; Mutagwaba et al., 2018). This makes these wards suitable for a study of this kind because, having attracted artisanal and small-scale mining for all this long, they understandably have a rich accumulation of IKS in relation to mining. From each ward, one village was involved in the study. Mgusu, Rwamgasa and Nyarugusu villages were involved in the study to represent the respective wards.

In-depth interviews, Focus Group Discussions (FGDs), observation and questionnaire tools were employed to capture the required information. Questionnaires with both structured and unstructured questions were administered to 98 participants who made 5% of the population of the villages aged from 35 years and above. The segment of the population selected was believed to have vast experience and knowledge for both mining and IKS. The technique was useful to understand the past and compare with the existing technologies used for identification, mapping and management of minerals. Questionnaires were filled by participants except where they were not ready, we then resorted to interviewing them using questionnaire questions, and this took an average of 45 minutes. The technique was useful for generating both qualitative and quantitative data. About 99% of the respondents were males and 1% was females. The women who responded to the questionnaire were those with administrative positions within the mining claims. The number of males far outweighed that of women because they were the bigger group of people directly involved in mining and most of them were willing to respond to the questionnaires, while most of the women who were available were not willing to. This is despite recent studies showing that women's participation in artisanal and small-scale mining activities positively impacts on women's decision-making power and changes socio-economic dynamics at the household level (Arthur-Holmes & Busia, 2020). This was attributed to the nature of community where the males are the ones needed to provide opinion about the community. It can further be attributed to the fact that women are traditionally not the custodians of indigenous knowledge applicable to male-dominated activities such as mining (Gregory et al., 2024; Khumalo et al., 2018), hence less interested in talking about indigenous knowledge systems in relation to locating and extraction of minerals. Even though greater women participation would have provided useful insights, their limited participation did not significantly undermine our findings because our paper focuses on mapping and extracting minerals using insights from IKS; these activities are generally male dominated. Some of the artisanal miners were not born in respective wards. For instance, of the 98 participants who were reached through questionnaires, 47 (about 48%) were migrants who came in the study sites from the neighbouring regions of Mwanza, Shinyanga, and Kagera. The rest were from within the Geita region. There were no participants from outside Tanzania in the study sites. Given that close to half of the study participants were migrants, this implies that there must be some diffusion and co-learning of different indigenous knowledge systems in the mapping and extraction of minerals. This is because migration reportedly plays a significant role in spreading indigenous knowledge systems beyond their traditional geographical location (Okoli, 2023). This notwithstanding, our findings show that the indigenous knowledge systems dominating and informing ASM mining in the study sites are informed by the cultures of the

surrounding communities. We were not able to determine indigenous knowledge systems and practices from beyond the study sites that may have influenced the mapping and extraction of minerals in ASM sites. This can be an area for further study.

The study employed snowball sampling technique to obtain participants for in-depth interview because it was difficult to locate participants of the study population with the required knowledge (Babbie, 2001). The first person was identified through village officials. This technique offered an opportunity for the known participants (village leaders and traditional priests/healers) to locate other participants who are known by them in terms of IKS and their understanding in mining activities. In this case, therefore, 11 participants were involved in the study through in-depth interviews.

Observation technique was employed throughout the study to observe and capture the non-verbal data relating to the traditional tools and indicators for decoding geological resources and their management. Digital camera was used to capture the information. Focus Group Discussions (FGDs) technique involved group interviews with a group of five to nine participants from the selected villages. FGD participants were believed to have knowledge of mining and considered by the community to be the key informants on traditional beliefs, taboos, rituals and rites as observed during interviews. The tool was used to harmonise and triangulate the prior collected data and conclude the reliability of the indicators used. In this case, therefore, a total of three FGDs were conducted in the study area meaning one FGD per village.

Documentary search involved the search of relevant information from various sources, which included books, journals, televisions, radios and internet sources. The technique was useful in reviewing the human activities, role of IKS and its trend in relation to mining sector in the study area and developing countries in general. The core functions of this tool were to substantiate findings including scientific implications of the identified indicators and compare them with the situation elsewhere.

Conversations with participants in interviews and FGDs were conducted in Kiswahili, Tanzania's national language that is spoken fluently by majority of Tanzanians. Questionnaires were also prepared in Kiswahili. Conversations from interviews and FGDs were captured and recorded using a digital voice recorder. Each interview and FGD session lasted for between 30 and 60 minutes. Both the interviews and FGDs were conducted by the paper's first author. Following data collection, the raw data from interviews and FGDs was transcribed verbatim and later translated into English by the researchers. Data were analysed using both qualitative and quantitative techniques. Summarisation of qualitative data was done first to reduce the bulkiness. Content analysis technique was employed to analyse data collected from the FGDs and in-depth interviews. Statistical Package for Social Sciences (SPSS) Version 20 was employed to analyse data that were collected through questionnaires. The resulting findings are subsequently presented in tables, figures and text.

Research findings and discussion

Historical discovery of minerals

Geita region is one of Tanzania's mineral rich regions hosting Geita Gold Mine. The region boasts of such minerals as gold, copper and iron. Copper and iron are not extracted

because they are found in small quantity. Regarding historical discovery of minerals, we visited the Geita Regional mining offices requesting for official documents containing information on discovery of minerals during the pre-colonial period; however, we could not obtain such documents. The limited information obtained about the historical discovery of minerals in Geita Region was from the Ward administrative officers, traditional healers and the artisanal miners. The discovery of minerals in the study area was mainly championed by iron, which was used for forging hoes, arrows and spears. This was the earliest discovery which is dated back to precolonial era. Historical accounts mention Geita to be one of the prominent iron smelting sites in precolonial Tanganyika with the Rongo smiths being the famous iron-smelters and workers of precolonial Tanzania (Koponen, 1988). This is evidence for there being iron mining and working in Geita during the precolonial era. It was noted that at Mgusu mining centre, the discovery of minerals was done by the local people before the coming of European colonialists. The study found out that the area experienced the presence of iron and copper before the colonial regime was established. It was noted that the clan of Marongo had technology of smelting such minerals and forging different tools. The Marongo clan is believed to be the champion of iron smelting in the lake zone. It is also believed to engage in smelting and forging farm implements like hoes, sickles and axes. The clan is also linked to the rituals related to minerals to date. In line with this paper, the Marongo could be said to have been custodians of indigenous knowledge system associated with iron extraction and smelting, including taboos that forbade women to come near iron smelters (Kimambo et al., 2017). As we show later in the paper, such taboos forbidding women participation are still in existence today despite increased efforts to promote women participation in ASM activities. This notwithstanding, most of the minerals in Geita Region were discovered during the colonial era. Gold was discovered during the colonial period making it to become the game changer in mining activity along the Lake Victoria zone. Gold has become the main mineral found and extracted along the Lake Victoria and Geita region is famous for that.

The Rongo people (marongo), who are also in some places known as Nyamarongo and were primarily farmers, discovered the minerals and used them for preparation of hoes and other appliances. They mainly used iron and copper to a lesser extent. After the discoveries, the Marongo community became the iron smelters and thus became the main producers of iron tools along the lake. The Marongo became rich as they were also exchanging iron tools for crops. It was then noted that the European miners came in with modern tools and undertook more discoveries and extraction. After independence local people then continued to extract minerals, especially gold, up to date.

Indigenous techniques employed in mineral identification and mapping

It was revealed that various techniques were used by artisanal miners and local people in mineral identification and mapping. One of the commonly used indicators was the type of trees associated with the presence of minerals. In all the three study wards, it was learned that the Miombo woodland is the main indicator for availability of minerals. Two species of Miombo (*Julbernardia globiflora* & *Brachystegia spiciformis*) locally named as *mitundu* and *miyenze* are popularly known to be the main indicators of the availability of minerals. It was also noted that the two different species of trees were noted as indication of the availability of minerals in Nyarugusu

and these were *mibanga* and *aobfe* trees. It was noted that the places where such vegetation is available, there was a great likelihood of finding gold. The use of certain species of plants as an indicator for locating mineral sites is not unique to Geita. Some academic analyses have noted that precolonial southern African societies used the growth of plants characteristically associated with gold bearing soils to locate gold mineral sites (Miller et al., 2000). It was noted that although this is the main indicator for mineral mapping, it does not stand alone; it must be associated with other indicators.

Another indicator that showed the likelihood of presence of minerals was the presence of a specific type of rocks. They used types of rocks available especially igneous rocks. The surface rocks with yellow/gold/grey strips (the strips are locally known as '*michirizi*, or '*sesa*') were considered as the sign of the availability of minerals and thus made them to take further steps by experimenting them. The experiment included testing of the mixture of rock powder and water in a saucer shaped apparatus made of steel. The apparatus used is locally known as '*testio*'.

The presence of red soil and scattered black stones were used as indicators that show there is the likelihood of having minerals underneath the soil surface. In this case, the red soil which is mostly associated with gold mines is that which is soft in nature thus loamy soils. An association between certain rock characteristics with mineral presence is also reported in other scholarly studies as a common indigenous strategy for locating mineral sites (Miller et al., 2000). These techniques, indigenous and traditional as they may seem, are a reflection of an embedded indigenous geological and botanical knowledge system that African societies have banked on to map and extract minerals for centuries (Bandama, 2020). That similar techniques are reported to have been used across southern Africa suggests the commonality of the indigenous knowledge and could be associated also with earlier Bantu migrations during the second millennium before the Christian era (Choudhury et al., 2021). Properly developed and supported, these can work alongside modern scientific techniques to locate mineral sites.

However, the technical mapping of minerals using traditional reading of geology, soil, and vegetation was not enough as it had to be complemented by the blessing, guidance, and intervention of the spirit world (Bandama, 2020), thus bringing in the use of rituals to map and extract minerals. In the study sites, we learned also that rituals and the help of traditional healers continue to be used for mapping and extraction of minerals. Some of the artisanal miners revealed the use of the traditional healers in mapping of the mineral belts. It was noted that the traditional healers have special insights on the mineral belts' location. The artisanal miners were given some challenges to overcome in order to reach the mineral deposit site. Such challenges were to fight a lion which is magic in nature. He who succeeds is given instructions to get gold deposits. It was noted that there were some people who used *ndago* (special instructions for identification of minerals). The following interview extracts allude clearly to the role of traditional healers in mineral discovery and extraction:

It is evident in Nyasale reserve where there is abundance of gold but if you need to take it, you must meet the traditional experts so as to obtain gold ... (WEO Rwamgasa, August 2016)

If the place is not cleansed, you cannot find gold, there is a specific place for offering and in the offered animals there are codes which show the problem or indicators for the ways of

solving the problems and pray to the owners of wealth to grant wealth to others. (The supervisor Mgusu mines, July 2017)

This supposed role of traditional healers in mineral site identification, mineral extraction and supposed 'luck' for artisanal miners has also been reported in extant scholarly analyses particularly in connection to the albino killings associated with mining in the Lake Victoria region (Bryceson et al., 2014). Whereas majority of the participants noted the role of traditional healers in mapping mineral belts, some of the artisanal miners denied the ability of the traditional healers in mapping of the mineral deposits. The following interview extract is clear on this:

It is just a myth, there is nothing like traditions that can bring gold. The belief of the jinn for bringing gold does not work although the miners believe on this and when they get gold, they think the jinn has brought it ... (Miyombo company manager, Rwamgasa 2017)

Indeed, as the above interview extract reveals, the use of traditional healers and rituals to locate mineral sites is much more a matter of belief than reality. That this continues to be used among the artisanal miners in the current world with advanced science and technology testify to the power and resilience of indigenous knowledge and practices; a testament to the fact that spirituality is an integral part of all life aspects of majority of the Africans (Paris, 1993; Swindell, 2019).

Indigenous knowledge practices in mineral extraction

If there is anywhere rituals are mostly used it is in the extraction of minerals. Findings from the three wards in Geita show that both small-scale and medium-scale miners employed certain kinds of rites and rituals in the extraction process. The rites and rituals were employed for the purpose of either cleansing the place from the previous actions that have removed its sanctity or attracting more minerals or showing new lines of minerals. The following interview extract provides some details on this:

We normally take local brews which are mixed with red millet then used in the mining pits coupled with special prayers to attract gold minerals. This is done where the challenge observed was considered to be small. Where the situation is tense, we offer animal sacrifices like cows, goats, and pigeons. (Supervisor at Mgusu mining site September 2016)

Some of the participants revealed that traditional priests may be more specific on which kinds of sacrifices are required. These normally include animals like white goats, black goats, white hens and white doves. The offering is done at the source of water or along the river present nearby a specific mining centre. The practice of rituals and sacrifices is very common in artisanal and small-scale mining across Africa. Several studies report on the practice of animal and human sacrifices by artisanal and small-scale miners in hopes for luck and prosperity in their mining activities in Tanzania, Ghana, Sierra Leone, and Burkina Faso (Bryceson et al., 2010, 2014; Cecilia & Amankwah, 2011; D'Angelo, 2015; Ouedraogo & Mundler, 2019; Sarpong, 2017). There seems to be an implicit belief that one cannot succeed in mining without resorting to ritualistic practices (D'Angelo, 2015; Sarpong, 2017). Figure 1 and Table 1 provide descriptive information on the use of rituals to locate and extract minerals.

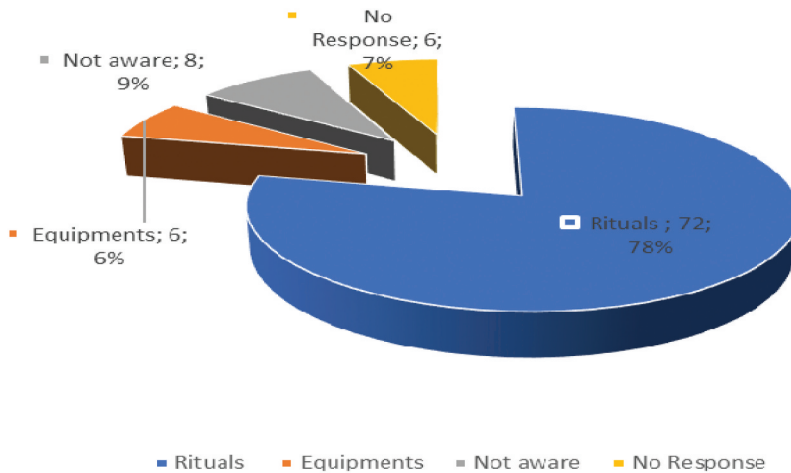


Figure 1. The perception on the methods used to discover and extract minerals in the study area.

Table 1. The responses on the use of rituals in discovery of mineral sites in relation to wards.

		Use of rituals	No use of rituals	Not aware	No response
Nyarugusu	Count	11	1	1	2
	% within Ward	73.30%	6.70%	6.70%	13.30%
	% within Discovery Rituals	16.40%	16.70%	20.00%	40.00%
Mgusu	Count	33	0	2	3
	% within Ward	86.80%	0.00%	5.30%	7.90%
	% within Discovery Rituals	49.30%	0.00%	40.00%	60.00%
Rwamgasa	Count	23	5	2	0
	% within Ward	76.70%	16.70%	6.70%	0.00%
	% within Discovery Rituals	34.30%	83.30%	40.00%	0.00%

Figure 1 shows that the majority of the participants noted rituals were used in discovery of minerals, while a very small proportion of the participants showed that modern equipment were used for mineral discovery.

Table 1 shows that majority of the participants in the study area used rituals in discovery of minerals. The findings showed that about 73%, 87% and 77% of the respondents from Nyarugusu, Mgusu and Rwamgasa, respectively, used rituals in discovery and extraction of minerals. It was noted that there was no evidence from any participant that discovery is not associated with rituals in Mgusu village.

The extraction is also associated with some taboos which prohibit people from different activities such as women not being allowed to visit mineral pits especially when they are in menstruation period. This goes with the belief that the mining sites are associated or owned by jinn which are interested in blood. It is believed that if a menstruating woman visits a mining site, the jinn will enter her and suck her blood and the woman would die. People are not allowed to arrive at the mining pit zone with coin shilling and skin made product like shoes and belts. It is strictly prohibited to urinate and defecate in a mining zone. It was believed that when people adhere to the existing taboos, they succeed to get gold but when they ignore the taboos, they cannot get it and sometimes be adversely affected. These taboos and practices are both common across Africa and have a long history

going back to the precolonial period (Cecilia & Amankwah, 2011; Kühn, 2017; Mathoho et al., 2016). During the precolonial period, for instance, observing such taboos as prohibiting menstruating women from entering the mines, sexual abstinence, among others, were commonly emphasised in mining activities (Mathoho et al., 2016; Van der Merwe & Avery, 1987). This is further emphasised by participants of this study. Interview with the traditional healers and those who offer the sacrifice and prayer services at Mgusu mining area showed that their experience in mining has a long profound history.

The Mgusu cooperative Society of miners is the registered association, and it is the one that bears the title of the twenty blocks at Mgusu. The society believes that minerals are associated with superstition and supernatural powers. These powers were normally vested into a certain group of people who can decode signs and get meaning out of them. In this case the *Marongo* clan was revealed to be the clan that knows what is happening in the area. This mining site is said to be under the *warongo* and their oracles are residing in this area. (Chairman of the Cooperative Union at Mgusu September 2016)

I have been working in mining for more than 25 years, I have worked in Tanzania and outside Tanzania ... we are using 'experts' [traditional priests] to succeed in our business. ... we have our own *ndagu*. (Artisanal miner at Mgusu, September 2016)

The study also revealed that traditional knowledge may be used in extraction and preservation of minerals.

In the last two years I witnessed the extraction of a lot of minerals in the *duara Na3* [Pit number 3]. In the process of sharing the wealth, the disagreement emerged. One man was furious and decided to quit the business. Immediately after his quitting, the test of those ores was negative as there was no gold observed as opposed to the first test which was good; thus the ore failed to get buyer. After three months, they had to convince that man to rejoin the business and he later accepted. Immediately after his return, the ores were retested and they showed to have minerals and thus managed to sell (Supervisor, Miyombo Company September 2017)

Majority of the participants in interviews and some participants in questionnaires revealed that modern miners also practice some rituals. Some of the companies were reported to undertake rituals during certain stages of their operations. Some of the companies offered sacrifices of cows, goats, pigeons, as well as sheep. Other companies threw certain kind of denomination of their motherland currencies which are associated with their own prayers which are not known by the local communities. However, in relation to specific wards involved in the study, it was shown that majority of the participants from Nyarugusu ward were not aware of the large companies' involvement in practicing rituals and the traditional beliefs in mining processes. This notwithstanding, it is important to note that these taboos and rituals are respected and feared because their contravention is believed to attract loss:

This is the naked truth that minerals are possessed by other creatures powerful than us. The experts know how to communicate and allow us have the resource ... Unfortunately, some of us do not abide by the instructions provided through the claim leadership, intentionally or accidentally. Gold vanishes, if you do not do something you will end up spending money and digging deeper while other claims are booming ... (Old man at Rwamgasa, September 2017)

From the above interview extract, it is apparent that disrespect of taboos and rituals is associated with hardship in securing minerals when mining. When this happens, the owners of the mining centres organise themselves to make sacrifices of cows, goats, sheep as well as local brews mixed with red millet. It is believed that this helps to restore the availability of minerals.

The potency of indigenous knowledge in mining is also seen in how miners characterise mining in different seasons. From interviews and FGDs, it was learned that the artisanal miners earn little due not only to the use of rudimentary tools but also due to seasons. It was revealed that in dry seasons the minerals are very scarce but increase in wet season. They believe that the minerals in wet season tend to go upward due to the uplift of water table. To increase mineral production in these different seasons, rituals must be performed by the traditional healers. They believe that no one can succeed in mining without the use of charms and rituals. The sacrifices are done in the water sources and at the mine tunnels locally named as *maduara*.

Traditional priests are not only consulted for determination of mineral sites but also for providing charms/medicines and conditions to be met for whoever needs to become rich and succeed in mining. Therefore, taking of charms and abiding to instructions provided was believed to help the miners to get rich through obtaining minerals by using little effort. In this case, the belief of the use of *ndagu* has been seemingly popular in all mining centres. *Ndagu* are also associated with sacrifices of animals.

Three days before the rituals, all people in the village should not work for three days because the owners of the wealth and place would be walking around and the committee for the rituals would make sure that all instructions are adhered to as preparation. After the rituals new instructions will be given and the duty of the committee is to make sure that the instructions are adhered to. . . . (The supervisor Mgusu mines, September, 2017)

The study revealed also that traditional priests burned frankincense and aloe within the *maduara* for the purpose of cleansing the mines and attracting minerals. It was believed that the frankincense and aloe are normally accepted by the jinn and thus they can be used to cleanse the premises and make the jinn comfortable to release the minerals to the miners. While the majority of participants alluded to the centrality of rituals, some few miners opposed the rituals in mining as they claimed to be religious and believed in God. Such opposition has also been reported in other studies (D'Angelo, 2015). This is ascertained by the interview as one of the respondents said:

There was another miner who was a saved person [literally: born-again Christian] who did not believe in traditional beliefs He used modern technology and was successful If the traditional beliefs could be strong then they could turn any mountain to be a gold deposit. . . . (Miyombo company manager, Rwamgasa 2017)

Even though such rituals and taboos have existed for ages and continue to be observed today, this does not mean that they are sacred and cannot be challenged. For instance, taboos on women participation in mines are gradually challenged by increased women participation in secondary mining activities in the artisanal and small-scale mining sites as well as some women self-initiatives to own pits and mine them. Even though women constitute only 5% of mining workforce in the artisanal and small-scale mining activities, with the rest majority in support activities (Huggins et al., 2024; Merket, 2018), the fact that they can access the mines in their few numbers means that the age-old taboos still in

use are ineffective and can be challenged. Further, that there has been a woman who disguised herself as a man (Pili Hussein disguised as Uncle Hussein) for 10 years and managed to successfully work in an underground tanzanite mine in Tanzania (Huggins et al., 2024; UN Women, 2017) also means that these taboos can be challenged. Indeed, these practices are increasingly challenged with governments urged to proactively address them and promote active women participation in mineral extraction (Mengba et al., 2023). Further, the existence of some miners who do not see value in rituals and taboos and have become successful without using rituals challenges the utility and infallibility of indigenous mining practices rooted in beliefs and rituals. This is why many of the miners we interviewed call on the government to support them to improve their production. They believe that by getting loans they will be able to buy advanced tools for production which will benefit both artisanal miners and the government.

Conclusions

Indigenous knowledge continues to be an important resource for Africa's development. Since the precolonial period, indigenous knowledge has been a critical ingredient of any development effort in the continent. While it may be tempting to think that modernisation and formal knowledge systems have rendered indigenous knowledge insignificant, evidence from across the world suggests that modernisation alone cannot sustainably solve the complex socio-economic challenges confronting the world. This paper considered the place of indigenous knowledge systems in the mining sector, especially with regard to determination of mineral sites and extraction of minerals. Drawing on insights from artisanal miners and other mining stakeholders in Geita, the paper has shown that indigenous knowledge exists side by side with modern knowledge systems and it is greatly consulted by the artisanal and small-scale miners and medium-scale miners for locating mining sites and in the extraction of minerals.

This paper has shown that: 1) in the absence of modern knowledge and technology for locating mineral sites, indigenous knowledge provides a much-needed resource for determining the location of minerals; 2) there is greater continuity in the practice of indigenous knowledge between what past societies used to do and what present generations do to apply indigenous knowledge. The taboos, rituals and sacrifices associated with indigenous knowledge as applied in mining today reflect long held knowledge and practices as inherited from precolonial times. The similarities in the practice of indigenous knowledge in artisanal mining across Africa also reflect the vibrancy and sustainability of the practices over time and space despite their interaction with modernisation; 3) Modernisation and advocacy efforts have failed to undo indigenous knowledge practices such as human sacrifices and prohibition of women from entering mining sites when in their menstruation because these have tended to criminalise and label indigenous practices as barbaric and ignorance without considering the context within which these take place and how commodity booms may be fueling them (Bryceson et al., 2010, 2014); 4) not all indigenous practices in mining are harmful; some are very beneficial and can be leveraged to be used alongside modern techniques. For instance, practices such as indigenous geological knowledge, use of vegetation and soil to determine potential mining sites can be promoted and studied further scientifically to determine their utility and scale them up; and 5) addressing

harmful indigenous practices such as rituals and taboos requires concerted efforts and investment in technical and financial capacity of artisanal and small-scale miners. The existence of miners who have become successful through using modern technology suggests that if investments are made to promote scientific prospecting and extraction, harmful practices can fade away.

Finally, the findings from this paper, apart from adding to the body of knowledge on artisanal mining and indigenous practices in Africa, highlight the importance of taking indigenous knowledge seriously in mining policy debates and reforms in Africa. Treating indigenous knowledge practices in mining as barbaric and outdated will not eliminate the practices. Recognising the role it plays and looking for ways on how to promote 'beneficial' indigenous knowledge practices (such as the use of certain tree species and rocks to locate mineral sites) may be a good starting point to mainstream IKS in mining policy.

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