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Original article

Human insecurities in gold mining: A systematic review of evidence from Ghana

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ABSTRACT

Adverse mining effects, notably the uncontrolled spread and consequences of artisanal and small-scale mining (ASM), are growing concerns in sub-Saharan Africa. A securitization discourse is often used to justify a military-style approach toward illegal mining but fails to acknowledge the multiple dimensions of insecurities arising from mining. A human security approach allows taking a more holistic perspective but has hardly been applied to the mining sector. We address this gap by unraveling the insecurities arising from gold mining in Ghana based on a systematic literature review of empirical studies on mining impacts across multiple disciplines. Results reveal that the reviewed literature predominantly focuses on environmental and health insecurities, less on economic, food, and community insecurities, and hardly on personal and political insecurities. Recommended governance responses increasingly call for multidimensional and integrated approaches, considering that gold mining – particularly ASM – is situated in multifunctional landscapes and part of multidimensional livelihoods. We conclude that a human security approach enables a comprehensive analysis of a country's mining sector but still bears the risk of a 'securitization trap'. We therefore advocate multistakeholder dialogue and integrated landscape approaches as the way forward to deal with the insecurities arising from a mining sector largely characterized by informality.

1. Introduction

The environmental and socioeconomic effects of mining and associated governance challenges are a cause of increasing concern worldwide, and Ghana is no exception. This is reflected in the growing body of literature on gold mining in Ghana, especially in the past 15 years (Fig. 1).[2] It is acknowledged that the extractive sector – notably gold, diamond, manganese, and crude petroleum - contributes considerably to the national economy. However, its adverse effects, notably on the environment and people's health, are increasingly acknowledged as well.

Thus far, these adverse effects have mainly been analyzed with a focus on specific dimensions such as environmental, social, or health impacts. Such a unidimensional focus is problematic as mining in the global South is intrinsically related to poverty (Gamu et al., 2015). The multidimensional nature of poverty (Alkire and Foster, 2011) requires a more holistic analysis of mining impacts on (poor) people's livelihoods. Against this background, this paper aims to unravel the multiple insecurities around gold mining in Ghana from a human security perspective. The second aim is to make an inventory of governance and policy suggestions in the literature to explore possible solutions for these insecurities. Hence, we address the following research question: What insecurities arise from Ghana's gold mining sector, and how can these insecurities best be addressed?

Although the human security approach was already developed in the 1990s (UNDP, 1994, 1993), its application to mining studies is relatively new (e.g., Engwicht and Grabek, 2019; Johnson, 2019). Traditionally, security studies focused primarily on international relations and global

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[2] Hits in the Web of Science generates similar results, with no publications prior to 1983.

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politics (see Williams, 2012), generally overlooking 'insecurities' that affect people's daily lives. Attention was paid to economic security, but this was usually framed in terms of access to financial resources and markets to sustain welfare and state power (ibid.). This state-focused definition of security changed with the call for a people-centered definition in the 1993 and 1994 Human Development Reports of the United Nations Development Program (UNDP, 1994, 1993). These reports reframed security as 'human security' or 'security for people' and distinguished seven dimensions that matter in people's day-to-day lives (UNDP, 1994). In our analysis we separate gender insecurities – in UNDP's human security report (UNDP, 1994) covered under personal security – as a distinct category because gender-specific impacts of mining receive growing attention (Table 1). This paper applies this human security perspective to Ghana's gold mining sector. The focus on Ghana is justified because the country is struggling to find a balance between the need to create employment, alleviate rural poverty, and generate foreign exchange, on the one hand, and dealing with the multiple adverse effects of mining, on the other. This dilemma notably plays a role in areas where illegal small-scale mining (colloquially referred to as *galamsey*) prevails.

The paper proceeds as follows. Section 2 briefly characterizes the Ghanaian mining sector. Next, we present the methodology (Section 3, Annex 1) and the evidence base (Section 4). The following two sections present the findings from the systematic literature review. In Sections 5, we analyze the insecurities arising from gold mining in Ghana, while Section 6 presents the policy and governance recommendations that arise from the literature. In the discussion, we synthesize the findings and reflect on the human security approach (7.1), address the limitations of this study (7.2) and the knowledge gaps identified (7.3), and discuss the governance implications (7.4). We answer the review questions and address the implications of our review for policy and the future research agenda in the conclusions.

Table 1
Insecurities derived from UNEP's (1994) dimensions of human security

Security dimension	Definition
Economic insecurity	Insecure income due to, for instance, a lack of permanent employment or negative impact on existing livelihood activities and insufficient damage compensation.
Food insecurity	Threats to stable access to affordable, healthy, and culturally appropriate food due to, e.g., rising food prices, soil damage, and pollution.
Environmental insecurity	Compromised access to clean drinking water and land and threats of rapid-onset disasters (e.g., flash floods) and slow-onset hazards (e.g., deforestation, climate change).
Health insecurity	Threats to health resulting from infectious and parasitic diseases and pollution.
Personal insecurity	Being subject to physical violence and a general feeling of unsafety.
Community insecurity	Threats to traditions and cultures, languages, and commonly held values; discrimination and conflict; lack of protection of indigenous people.
Political insecurity	Disrespect of fundamental human rights (freedom of speech, press, and voting) and absence of the rule of law (e.g., no access to justice, corruption).
Gender insecurity	Reinforcement of gender roles that result in unequal access to work, resources, and benefits.

Source: Adapted from UNDP (1994).

lead, natural gas, salt, sand, and silver are also explored (Hilson, 2016; Perez, 2003). Before discovering the Jubilee Field in 2007 and the start of off-shore oil extraction in 2010 (Skaten, 2018), gold comprised 90-95% of Ghana's total mineral exports (Aryee, 2001). In terms of export value (USD 10 billion), gold still is Ghana's major export commodity, outpacing crude petroleum, which has an export value of USD 4.65 billion (OEC 2021).[3] In terms of contribution to the gross domestic product, the mining sector impairs the adage 'Ghana is cocoa and cocoa is Ghana': the mining sector (4.5%) is more important to the country's economy than cocoa (1.4%). Formal employment in the mining sector

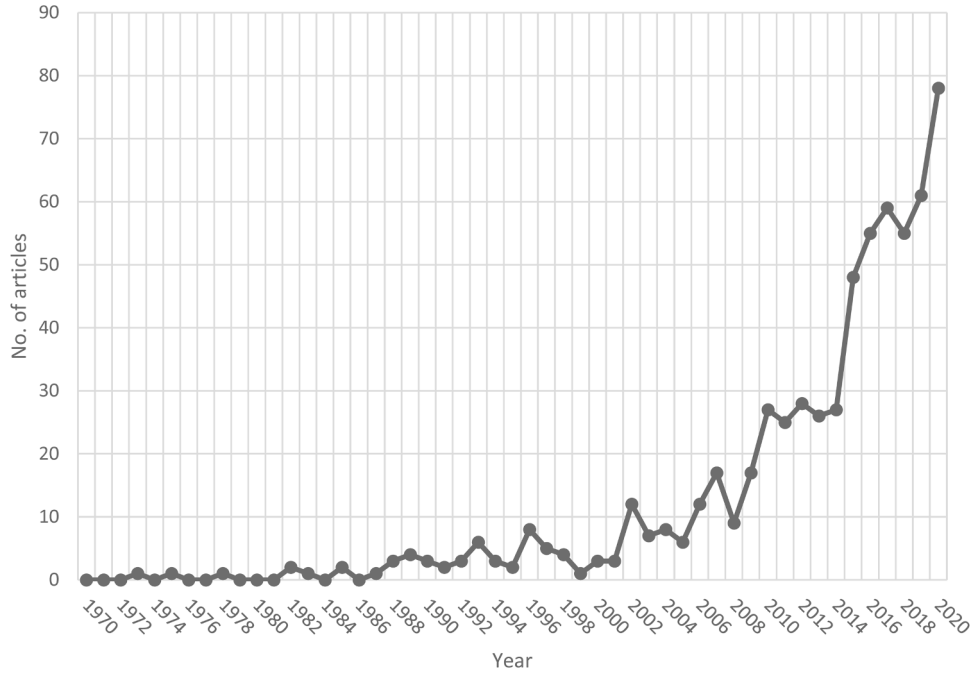

Figure 1. Number of publications on mining in Ghana from 1970-2020 (*Source*: Scopus)

2. Ghana's mining sector

Ghana sits on a broad range of mineral reserves: gold, oil, gas, bauxite, manganese, and diamonds, but aluminum, bauxite, cement,

[3] URL: http://OEC.world/en/profile/country/gha, last accessed 25 February 2021.

(42,576 people) lags behind the number of people living off cocoa (approximately 800,000 families[4]), but when taking estimates of ASM workers into account (1.1 million), mining ranks higher (Table 2) (GSS, 2019, 2015; Hilson, 2016; Perez, 2003). The gold reserves are found mainly in the Birimian and Tarkwian gold belts in the Western, Central, and Ashanti Regions (Hilson, 2002).

Ghana's mining sector knows a marked distinction between large-scale mining (further abbreviated as LSM) and artisanal and small-scale mining (ASM). The LSM sector encompassed 14 companies in 2016, operating from 11 mines, and extracting gold, bauxite, manganese, oil, and gas (Hilson, 2019; Ministry of Finance, 2018). The ASM sector is mostly informal and illegal and, above all, highly heterogeneous (Ferring et al., 2016). It knows several forms, with different degrees of mechanization and labor organization, ranging from simple gold panning in river beds to highly mechanized operations (Yankson and Gough, 2019). The most common form is 'dig and wash', also known as 'tally panning' (Ferring et al., 2016). It comprises retrieving gold by a 'gang' of 3-5 people from heaped gold sands dug out by another 'gang'. Perforated blankets are then used to separate gold-containing fine sand from coarse sand and gravel, while mercury is used to separate the gold from the fine sand. Other manual forms include 'carry [from a pit] and dump' carried out in gangs of about ten miners and scavenging (locally called *kolikoli*), usually carried out by approximately five women re-washing tailings at an abandoned ASM site. Mechanized forms include Trommels (wash plants) and Changfans (crushing machines to grind gold-bearing rocks) – named after the brand names of the machines – used to recover alluvial gold from river beds (Aggrey, pers. obs.; see also Ferring et al., 2016). Local variations on these methods exist.

Considering that large-scale companies generally mine below-ground and ASM mainly engages in surface mining, the two sectors may co-exist relatively peacefully on the same ground (Yankson and Gough, 2019). In such cases, conflicts mainly occur where small-scale miners illegally encroach on concessions (Hilson, 2002). However, hostile (and often violent) encounters have increased due to four reasons, two of which are related to Ghana's mining policy.[5] First, instigated by World Bank and IMF policies, the Ghana government incentivized foreign investment in the extractive industry to create employment and foreign exchange, resulting in an expansion of LSM (Patel et al., 2016). Second, efforts of the Ghana government to formalize the mining sector prioritized large-scale companies over small-scale miners in giving access to mining lands (Hilson, 2002; Yankson and Gough, 2019). This resulted in small-scale miners' marginalization and criminalization, culminating in a ban on ASM from March 2017 to December 2018 (Owusu et al., 2019; Tuokuu et al., 2020). Third, conflicts increased since large-scale companies increasingly engage in open-pit surface mining, as a result of which both sectors compete more directly for the same land and the same resource (Patel et al., 2016; Yankson and Gough, 2019). Fourth, the increasing presence of Chinese investors in the ASM sector has increased mining conflicts between various actors across the board (see Sections 5.4-7) (Boafo et al., 2019; Crawford and Botchwey, 2017; Hilson et al., 2014).

Table 2
Contribution of the mining sector to the Ghanaian economy

Contribution	Value	Reference year	Source
Real Gross Domestic Product	4.5%	2019	(GSS, 2019)
Export value – gold	USD 10 bln	2018	(OEC 2021)[a]
Export value – crude petroleum	USD 4.65 bln	2018	(OEC 2021)
Direct employment	42,576 people	2015	(GSS, 2015)
Estimated number in ASM	1,100,000 people	unknown	(Hilson, 2016)
Corporate tax earnings	38%	2011	(Amoatey et al., 2017)
Government revenue	27.6%	2011	(Amoatey et al., 2017)

[a] URL: OEC.world/en/profile/country/gha, accessed 25 February 2021.

3. Methods and materials

This paper analyzes the human insecurities related to gold mining in Ghana. We focus on Ghana – a country with a long history in gold mining – because the effects of ASM, particularly *galamsey,* are of topical societal concern and subject to considerable debate due to its association with poverty, illegality, and security issues. The analysis is based on eight human (in)security dimensions (Table 1). The analysis is based on a light version of a systematic literature review of qualitative and quantitative empirical studies on gold mining impacts, using systematic search and review methods to critically assess *all* that is known about the topic (Booth et al., 2012). This review method involves (i) the definition of a review question or a set of related review questions, (ii) a systematic literature search, (iii) screening and selection of studies based on clear and specific inclusion and exclusion criteria, and (iv) a narrative synthesis of included studies (Khangura et al., 2012).

Based on the research question formulated in the introduction, the review addresses two questions:

1. What human insecurities arise from Ghana's gold mining sector?
2. How can these human insecurities best be addressed?

Table 3 specifies the inclusion and exclusion criteria, using the population, interventions, comparator, outcome (PICO) framework. The review captured articles retrieved from the Web of Science and Scopus databases published between 2011 and 2020. Books were excluded because of accessibility problems during the COVID-19 pandemic and because it is not always clear if these are peer-reviewed, which was an essential selection criterion. A total of 349 records were retrieved from the two databases, of which 217 remained for full-text screening after removing duplicates, resulting in 97 studies that met the inclusion criteria. Further details of the screening process (step ii) and the PRISMA[6] flow diagram can be found in Suppl. Material (Annex 1). We stored all references in Mendeley Desktop. Full texts were screened for relevant information, searching for terms related to human insecurities (listed under 'outcomes' in Table 4) and recommendations for policy and governance. Extracted data was tabulated in an Excel file, with a column each for the reference, the focus of the study, whether it referred to LSM or ASM, the human (in)security dimensions listed in Table 1, and policy and governance recommendations. A narrative synthesis was chosen to present the analysis results (step iv), alternated with tables and graphs where appropriate. After presenting the characteristics of the evidence base in the next section, Section 5 presents the human (in)securities synthesis.

4. Characteristics of the evidence base

Most scholarly attention (59% of the reviewed studies) goes to the effects of the ASM sector (Table 4). Socioeconomic studies and chemical

[4] https://www.cocobod.gh/home_section.php?sec=1, last accessed 25 February 2021.

[5] Ghana's mining policy is enshrined in the 1986 Minerals and Mining Act (PNDCL 153), which created favorable tax conditions for foreign large-scale mining companies. The Environmental Protection Agency was created through the 1994 EPA Act to ensure public participation and environmental sustainability. Policies regarding the latter are, however, ill-implemented (Tuokuu et al., 2018). For a more in-depth analysis of Ghana's mining policies, see Hilson & Hilson (2017), Li et al. (2020), and Tuokuu et al. (2018).

[6] PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Table 3
Inclusion and exclusion criteria based on the population, interventions, comparator, outcome (PICO) framework.

	Included	Excluded	Search terms
Population	Studies on gold mining in Ghana Studies on the impacts of mining	Studies on other minerals Studies referring to other countries	gold AND mining AND Ghana
Interventions	Studies on the direct effects of mining	Studies on technological aspects of mining Studies on marketing Studies on the effects of CSR policies or compensation packages Studies on government policies or programs Studies on international agreements and standards	effect* OR risk* OR implication* OR impact* OR assess*
Comparator	Large-scale mining (LSM) vs. artisanal and small-scale mining (ASM) Surface vs. underground mining Positive vs. negative effects Gendered effects		
Outcome	Articles that document how mining affects a) income, livelihoods, paid work (economic insecurity), b) food security, c) health insecurity, d) drinking water, soil, forests (environmental security), violence (personal insecurity), conflicts, traditions, values, exclusion, discrimination (community insecurity), freedom of speech, exclusion (political insecurity), gender relations (gender insecurity).	Studies that list effects based on secondary sources only Studies that list effects based on hypotheses only ('this may affect…') Baseline studies prior to mining activity Studies that focus on effects on urbanization, unrelated to one of the human security dimensions	
Additional criteria	Studies published in the period 2011-2020 Articles in English Studies based on primary data Peer-reviewed articles Accessibility	Studies published before 2011 Non-English articles Review papers Studies based on secondary data Articles not accessible online	

analyses (heavy metal pollution) prevail with 27% and 26%, respectively, followed by health and epidemiological studies (17.5%) (Table 5). Among studies on LSM, 25% deal with specific issues such as ecosystem health assessments (Kyerematen et al., 2020), radiation measurements (Faanu et al., 2011; Gbadago et al., 2011a, 2011b), and greenhouse gas emission assessment (Amoako et al., 2018). ASM studies often focus on communities, and LSM studies on concessions. Studies that cover both often encompass multiple districts (Armah et al., 2012; Armah and Gyeabour, 2013; Osei-Asare et al., 2018; Tay et al., 2019), an administrative region (Patel et al., 2016), or river basin or estuary (Akabzaa and Yidana, 2012; Awotwi et al., 2019; Hilson et al., 2018; Okyere and Nortey, 2018). Compared to studies focusing on either ASM or LSM, these mixed studies use GIS relatively more often (Awotwi et al., 2018; Obodai et al., 2019; Patel et al., 2016) (Table 5). One spatial study specifically analyzed conflicts between ASM and LSM (Patel et al., 2016).

Table 4
Main characteristics of the inventoried studies

Focus of study	Number of articles	
	n	%
Scale		
ASM	57	59%
LSM	26	27%
Both ASM and LSM	14	14%
TOTAL	97	100%
Human security dimension [a]		
Environmental	70	72%
Health	60	62%
Food	17	18%
Economic	32	33%
Personal	16	16%
Community	24	25%
Political	10	10%
Gender	15	15%
Single focus	35	37%
Multiple foci	62	63%

[a] 62 studies address multiple human security dimensions.

Table 5
Type of study and scale of gold mining addressed

Type of study	Scale			TOTAL
	ASM	LSM	Both/ unspecified	
Socioeconomic	18 (31.5%)	5 (20.8%)	3 (18.8%)	26 (26.8%)
Chemical	18 (31.5%)	4 (16.7%)	3 (18.8%)	25 (25.8%)
Health/ epidemiological	12 (21.1%)	3 (12.5%)	2 (12.5%)	17 (17.5%)
GIS	1 (1.8%)	2 (8.3%)	3 (18.7%)	6 (6.2%)
Mixed	1 (1.8%)	4 (16.7%)	5 (31.2%)	10 (10.3%)
Other [a]	7 (12.3%)	6 (25.0%)	-	13 (13.4%)
TOTAL	57 (100.0%)	24 (100.0%)	16 (100.0%)	97 (100.0%)

[a] Including biological, gamma spectrography, greenhouse gas emission assessment, emergy analysis[b], water runoff analysis, histography, and production factor analysis.

[b] Emergy analysis is a form of sustainability assessment method developed by Odum (1996), which is based on an environmental accounting system which expresses the value of natural resources and environmental services in a common value based on the total of solar energy required to make a product or service (Odum, 1996, cited in Asamoah et al., 2017: 9). Emergy is expressed in solar equivalent Jules (seJ).

Nearly two-thirds of the studies address multiple dimensions of human security (Table 4). The 35 studies with a single focus mainly address health (23; 66%) and environmental insecurities (9; 26%), with one study each (~3%) focusing on economic, community, and gender insecurities, respectively. Environmental insecurities are of most concern (addressed in 72% of the studies), followed by health (62%) and economic (33%) insecurities.

The effects under study were not framed as human security concerns. A few studies mention food, job, or livelihood insecurity, or 'security issues' in general. Only one study explicitly refers to human security, interpreted in the narrow sense of safety issues associated with armed thugs in the gold mining sector (Nyame and Grant, 2014) – which aligns with the notion of personal human insecurity in Table 1.

5. Human insecurities resulting from gold mining

This section analyzes the positive and negative effects of gold mining (LSM and ASM) in Ghana in terms of the dimensions of human (in)security highlighted in Table 1.

5.1. Environmental insecurity

Many of the human insecurities addressed in this paper originate from the environmental effects of gold mining. Heavy metal pollution and associated effects on drinking water and health was the most addressed environmental issue (44%). This pollution originates from both LSM and ASM, except for mercury (Hg), which is only reported for ASM (21%). With 10% of studies with an environmental focus, those on deforestation and ecosystem and land degradation rank third. Much less attention goes to radioactivity (9%), hydrology changes (3%), greenhouse gas emissions (1.4%), and oil and grease contamination (1.4%). Seven studies (10%) address multiple environmental problems (Suppl. Material, Annex 2).

5.1.1. Deforestation, land degradation, and hydrological effects

Kumah and Adum Nyarko (2018) give a concise overview of gold mining effects on forests, land, and water bodies, distinguishing between LSM and ASM. LSM results in land degradation due to the use of heavy machinery; deforestation and ecosystem degradation resulting from the removal of vegetation, soil, and rock in surface mining; leaching of heavy metals from tailings (piles of mining waste); and discharge of cyanide used in blasting operations leading to soil and water pollution. Similar findings were reported in a study on LSM by Antwi et al. (2017).

ASM disturbs the drainage system through the sluicing process, which uses a lot of water to separate gold from the gravel. The water washes the lighter gravel away using gravity, subsequently polluting rivers and streams with solid particles (Kumah and Adum Nyarko, 2018). Mercury is used in ASM as an economical and easy method to extract the gold from the ore by amalgamation (Ahiamadjie et al., 2011; Akabzaa and Yidana, 2012). When the amalgam of gold and mercury is burnt to capture the gold, the mercury is released into the air and disposed of in water bodies in the form of acid rain, leading to pollution of air and drinking water sources (Gyamfi et al., 2020). Mining requires removing vegetation cover, leaving the land bare and subject to soil erosion, subsequently leading to siltation of water bodies (Kumah and Adum Nyarko, 2018). Where more sophisticated machinery is used, such as bulldozers and excavators, considerable damage is caused to land, forests, and water bodies (Eduful et al., 2020). After an ASM operation, the landscape and farming lands are heavily degraded: “leav [ing] behind ‘moon-like’ landscapes consisting of unstable piles of waste, abandoned excavations and vast stretches of barren land” (Aryee et al., 2003: 135 cited in Kumah and Adum Nyarko, 2018: 143). Land reclamation seldom happens, particularly in transitionary mining cases where miners move from one gold mining site to another (Nyame and Grant, 2014). This, in turn, may create economic (livelihood) and food insecurities (see 5.3 and 5.4).

Studies that specifically highlight changes in the hydrological system – all focusing on ASM – point to the disruption of river systems through the diversion of streams and rivers to wash sediment (Botchwey et al., 2019; Hausermann et al., 2018) and increased runoff due to reduced infiltration capacity (Awotwi et al., 2019, 2017). This creates insecurities due to flooding risks during the rainy season, soil erosion and sedimentation, and pollution of water bodies (Awotwi et al., 2019, 2017; Botchwey et al., 2019; Hausermann et al., 2018).

5.1.2. Heavy metal pollution and radioactivity

Heavy metal and toxic element contamination of soils, water, and crops are major concerns in the reviewed studies (Suppl. Mat., Annex 1). In addition to mercury (Hg), most attention goes to elevated levels of arsenic (As), lead (Pb), copper (Cu), and cadmium (Cd). Arsenic occurs naturally in areas with gold deposits, usually making up about 5% of the ore, and is released in the gold extraction process (Adu-Poku et al., 2019). Similarly, lead, copper, and cadmium, but also iron (Fe), chromium (Ch), zinc (Zn), and magnesium (Mn) are natural components of the ore, which are released through leaching from mine tailings (Akoto et al., 2018; Kortei et al., 2020). Table 6 shows that reviewed articles analyzed toxic content of soils and sediments, water bodies and groundwater, crops, food animals (chicken, goat, sheep), and fish.

Values of several heavy metals (notably arsenic, mercury, lead, and cadmium) were above the recommended guidelines (Table 6). Where values remained below admissible values, there was often a ‘but’ such as in the study by Hadzi et al. (2019), who found acceptable concentrations of arsenic in soils for adults, but not for children. Another example is a study on heavy metals in fish, which found that all studied metals remained below recommended values, but not if the fish would be eaten daily (Gbogbo et al., 2018). A study on heavy metal concentrations in food animals (chicken, goat, sheep) found no excess levels. However, they warned against eating chicken gizzard and liver, especially by children (Bortey-Sam et al., 2015b).

Eleven reviewed studies report unsafe drinking water due to heavy metal pollution. This pollution originated from both LSM (Bempah et al., 2016; Bortey-Sam et al., 2015a), ASM (Affum et al., 2016; Ansa-Asare et al., 2015; Antwi-Boateng and Akudugu, 2020; Dorleku et al., 2018; Obiri et al., 2016a, 2016b; Ofosu-Mensah, 2017) and areas with a combination of those (Akabzaa and Yidana, 2012; Armah and Gyeabour, 2013). Heavy metals from LSM are mainly arsenic, cadmium, copper, nickel (Ni), magnesium, and zinc, whereas mercury prevails in ASM, next to arsenic, cadmium, and lead.

None of the studies focusing on radioactivity found values beyond the recommended guidelines. This suggests that gold mining does not pose any significant radiological hazard of concern to the surrounding communities (Doyi et al., 2013; Faanu et al., 2014; Gbadago et al., 2011a, 2011b; Klubi et al., 2017). Only one study found that children

Table 6
Heavy metal concentrations beyond recommended guidelines[a]

Concentrations examined	Metals beyond critical values	References & focus LSM	ASM	Both
In soil/ sediments	As, Hg, Pb, Cd, Cu, Cr	(Hadzi et al., 2019)	(Obiri et al., 2016b)	(Akoto et al., 2018; Armah et al., 2012; Armah and Gyeabour, 2013)
In water	As, Hg, Pb, Cd, Cu, Zn, Ni, Fe, Mn	(Bempah et al., 2016; Bempah and Ewusi, 2016; Bortey-Sam et al., 2015a)	(Amoakwah et al., 2020; Attiogbe et al., 2020; Dorleku et al., 2018; Klubi et al., 2018; Obiri et al., 2016a, 2016b)	(Akabzaa and Yidana, 2012; Tay et al., 2019)
In crops, food animals, and fish	As, Pb, Hg	(Bempah and Ewusi, 2016; Bortey-Sam et al., 2015b)	(Gbogbo et al., 2018; Kortei et al., 2020)	(Ahiamadjie et al., 2011)
In the human body	As, Cd, Cr, Pb, Hg, Mn		(Adu-Poku et al., 2019; Basu et al., 2011)	(Armah et al., 2012)

Key: As=arsenic, Cd=cadmium, Cr=chromium, Cu=copper, Fe=iron, Hg=mercury, Mn=magnesium, Ni=nickel, Pb=lead, Zn=zinc

[a] Reviewed articles used various reports and guidelines on admissible trace elements in human nutrition, drinking water quality, and exposure factors published by the WHO/FAO, US Environmental Protection Agency (USEPA), and national bodies (New Zealand, Ghana).

under one year might receive doses about 10% more than the reference limit recommended by the World Health Organization (Gbadago et al., 2011b). The health insecurities associated with toxic metal concentrations due to gold mining will be addressed in Section 5.2.

5.1.4. Other environmental insecurities

A study analyzing greenhouse gas emissions from LSM estimated that Ghana's LSM sector contributes about 11% of the country's total greenhouse gas emissions (Amoako et al., 2018). The emissions were attributed to land use, blasting, fuel and electricity use, and waste management. Electricity use and the fuel used for transportation accounted for 92% of the sector's emissions.

Mantey et al. (2020) observed high oil and grease contamination in ASM due to spilling and leakage of gasoline, lubricating oils, diesel, and other heating oils used in vehicles, processing plants, motors, pumps, and other mining equipment. Compared with underground operations, such contamination was particularly high in surface mining.

A different kind of environmental concern is environmental injustice (distributive, procedural, and recognition-based). Based on a study of the LSM company AngloGold in Obuasi (Ashanti Region), distributive injustice occurs due to the disproportionate distribution between the company and communities of environmental goods (e.g., land) and 'bads' (environmental burdens such as water pollution, land degradation, and air pollution due to blasting) (Wan, 2014). This form of injustice extends to future generations due to the neglect of sustainability principles. Procedural injustice means that not all are treated equally in terms of rules, access to information, and clarity of processes related to – in this case – compensation and resettlement. Recognition-based injustice translates into the psychological effects of misrecognizing power differences (between companies and communities and between traditional authorities and community members) and the value of farming to the lives of community members.

5.2. Health insecurity

Health is the second most addressed human insecurity dimension in the gold mining literature on Ghana (62% of the reviewed articles) and is often addressed in tandem with environmental concerns. Particularly the health risks associated with heavy metal pollution (43% of the health studies) and mercury (exclusive attention in 23% of the health studies) receive ample scholarly attention (Annex 3). The effects of radionuclides (naturally occurring radioactive material) (7%), injuries (7%), abandoned mining pits (5%), dust (3%), and a cholera outbreak in one mining site (2%) are much less addressed. Six studies (10%) address multiple health risks.

Annex 4 gives a comprehensive overview of the potential health risks and those actually reported in the reviewed studies. This overview shows that *the potential* health risks of toxic metal pollution are bigger than those *reported* based on primary data. Reported health problems associated with toxic metals are mostly related to the use of mercury in ASM and include itchy/red eyes, fatigue, chronic headache, numbness, metallic taste, and skin rashes (Afrifa et al., 2017; Kumah and Adum Nyarko, 2018; Mensah et al., 2016). Only a limited number of studies report actual health problems related to heavy metal pollution, despite many studies reporting elevated concentrations of heavy metals in soil, water, food, or the human body (Table 6). These studies mainly document a higher prevalence of diseases resulting from arsenic contamination, including skin, lung, liver, blood, and breast cancer (Armah et al., 2012; Attiogbe et al., 2020); respiratory infections, diabetes mellitus, and skin diseases (hyperkeratosis, skin pigmentation) (Armah et al., 2012); neurological problems (Basu et al., 2011); and diarrhea (Attiogbe et al., 2020). Attiogbe et al. (2020) report kidney infection and diarrhea related to cadmium pollution. Other studies used hazard quotients and indices for health risk assessment, reporting unacceptable cancer and non-cancer risks from pollution with a combination of heavy metals (Ansa-Asare et al., 2015; Bempah et al., 2016; Bempah and Ewusi, 2016), or specifically arsenic (Akoto et al., 2018; Bortey-Sam et al., 2015a; A. K. Mensah et al., 2020), chromium (Armah and Gyeabour, 2013), or mercury (Gyamfi et al., 2021, 2020). Such risks are highest for children (Akoto et al., 2018; Armah and Gyeabour, 2013; Bortey-Sam et al., 2015b; A. K. Mensah et al., 2020).

Health issues related to radionuclides (naturally occurring radioactive particles that may come to the surface due to mining and pose lung cancer risks) were examined but not found: all values remained under the ICRP[7] and WHO reference levels in all studies (Doyi et al., 2013; Faanu et al., 2011; Gbadago et al., 2011a, 2011b; Klubi et al., 2020, 2017).

Six studies report risks of abandoned and uncovered gold mining pits filled with water (Baah-Ennumh and Forson, 2017; Ferring and Hausermann, 2019; Hausermann and Ferring, 2018; Kumah and Adum Nyarko, 2018; Ofosu-Mensah, 2017; Wan, 2014). These risks include falling ('death traps') or drowning and being turned into mosquito breeding sites, which increases malaria incidence.

Two studies address the effects of dust exposure in LSM with mixed results. Assumed effects on pulmonary and respiratory diseases and vascular problems (e.g., high blood pressure and blood coagulability) did not emerge among self-reported health problems in a study among miners in the Upper West Region in Ghana (Antabe et al., 2017). However, elevated incidences of respiratory infections and lung diseases (asthma, pneumonia, bronchitis, emphysema, and tuberculosis) were reported by Ayaaba et al. (2017), Baah-Ennumh and Forson (2017), and Jonah and Abebe (2019), with odor annoyance from dust reported by Antabe et al. (2017).

Studies on injuries document bruises, wounds, lacerations, contusions, and fractures resulting from slipping and falling, being hit by (falling) objects, or handling equipment and tools (Amponsah-Tawiah et al., 2014; Calys-Tagoe et al., 2017; Nakua et al., 2019b). These injuries were attributed to the non-use of personal protective equipment (PPE), high working pressure, overtime work, and using obsolete equipment (Ibid). The injury rate was higher among *galamsey* miners (29%) than company miners (23%) (Nakua et al., 2019a), higher among workers in unlicensed ASM operations (6.1 injuries/100 person-years) than in licensed ones (4.2/100 person-years), and higher among females (11.97/100 person-years) than among males ((5.03/100 person-years) (Calys-Tagoe et al., 2017).

One study reports on a cholera outbreak in East-Akim Municipality (Eastern Region), with 40% of the patients being *galamsey* miners, which is related to the inadequate provision of clean drinking water and sanitation at such mining sites (Opare et al., 2012).

Last but not least, several studies report the psychological effects of mining. Wan (2014) attributes these to misrecognition of the cultural importance of farming where farmers risk losing their farmland to mining operations or inadequate compensation in case of displacement. Adverse psychological effects may also result from stress at work, continuous noise, gender-based discrimination at the working place, perceived injustice, fear of losing farming land, land grabbing, and anxiety about work safety and adverse effects on health, livelihoods, and wellbeing more broadly (Antabe et al., 2020; Hausermann and Ferring, 2018; Wan, 2014). A specific form of distress is solastalgia, the loss of sense of place and belonging resulting from environmental and landscape change (Antabe et al., 2020). Ferring and Hausermann (2019) point to psychological distress among women, resulting from concerns about increasing malaria infections in their children and associated health costs; polluted water sources; and destroyed farming land, which puts pressure on the availability and price of cassava, plantain, and other food crops and results in worries about being able to feed their children adequately.

In summary, based on health risk assessments, self-reporting by interviewees, information from health agencies, or epidemiological

[7] International Commission on Radiological Protection.

studies, the reviewed studies reveal considerable health insecurities caused by ASM and LSM, both physically and psychologically.

5.3. Food insecurity

Most of the 17 studies addressing the effects of gold mining on food security report pollution with arsenic, lead, cadmium, or cyanide from LSM and concentration of these toxic metals in food animals, fish, and food crops (Ahiamadjie et al., 2011; Amoakwah et al., 2020; Bempah and Ewusi, 2016; Bortey-Sam et al., 2015b; Wan, 2014). For ASM, mercury pollution is usually the primary cause (Ahiamadjie et al., 2011; Amoakwah et al., 2020; Ferring and Hausermann, 2019; Kortei et al., 2020). Other factors contributing to food insecurity are declining farmland and productivity (Antwi-Boateng and Akudugu, 2020) and spiking food prices due to declining food production and rising demand from migrants (Agyei-Okyere et al., 2019; Botchwey et al., 2019; Hausermann et al., 2018). These effects hit vulnerable people like the disabled (Agyei-Okyere et al., 2019) and women with marginal mining jobs (Arthur-Holmes and Abrefa Busia, 2020) hardest. However, malnutrition in children had improved in an LSM area, assumedly due to better birth attendance and infant care in mining districts. Whether the latter stems from changes in the market-based economy, corporate social responsibility policies, or public spending is unclear (Benshaul-Tolonen et al., 2019). Hausermann et al. (2018) show how interlinked factors jointly create food insecurity: heavy mining machinery disrupts soil structure and hydrology, thereby disturbing food production; farmers moving into mining no longer sell food crops to a nearby market town, unsettling food systems and trade networks; and higher food prices create financial stress.

Others found that despite ASM becoming more important than farming, households continue growing food crops (Hilson et al., 2013). It was also observed that women miners contributed to their households' food security and that it was the ban on ASM rather than their engagement in gold mining that created food insecurity (Kumah et al., 2020; Zolnikov, 2020). Finally, several studies found that heavy metal concentrations in fish, food animals, and crops remained within permissible values (Bortey-Sam et al., 2015b; Gbogbo et al., 2018).

5.4. Economic insecurity

Most of the reviewed studies addressing economic insecurities (87.5%) report harmful effects of gold mining on livelihoods. However, some of those acknowledge positive effects on employment and income-generating activities such as food vending and petty trade (Antwi-Boateng and Akudugu, 2020; Antwi et al., 2017; Azumah et al., 2020; Baah-Ennumh and Forson, 2017). Studies on LSM particularly mention adverse livelihood effects due to seizure of farming land and relocation without adequate compensation (Antabe et al., 2017; Aragón and Rud, 2016; Osei-Asare et al., 2018; Schueler et al., 2011); pollution of farming land with heavy metals (Aragón and Rud, 2016; Wan, 2014); and higher living costs (Agyei-Okyere et al., 2019). Studies on ASM particularly emphasize the loss of farming land through irreversible topsoil damage from pitting and trenching, and through water and soil pollution, with inadequate commitment and capacity of miners to reclaim the land after mining (Armah et al., 2013; Ferring and Hausermann, 2019; Kumah and Adum Nyarko, 2018; Obiri et al., 2016a; Ofosu-Mensah, 2017; Osei-Asare et al., 2018). Some studies additionally describe how farmers (notably sharecroppers) lose land through outright dispossession (land grabbing). Others are forced to sell due to flooding caused by mining in a neighboring plot (Hausermann et al., 2018). Access to land also becomes increasingly challenging by inflating land prices, amongst other factors caused by the Chinese investors' preparedness to pay large sums of money to gain access to mining land (Hilson et al., 2014).

Gold mining also absorbs labor force from agriculture (Antwi et al., 2017; Aragón and Rud, 2016) and fishing (Hirons, 2014), improving income in the short term but compromising sustainable income in the long term. Especially young people are attracted by the 'quick money' that mining generates (Antwi-Boateng and Akudugu, 2020; Azumah et al., 2020; Baah-Ennumh and Forson, 2017).

At odds with studies that emphasize that mining income is unsustainable compared to the activities that it replaces, Hilson et al. (2013) argue that ASM brought considerable wealth to the poverty-stricken North of Ghana, supporting subsistence farming, preventing out-migration, and stabilizing the economy. Two other studies reporting positive economic effects rather than insecurities analyzed topics usually considered controversial. One of these studies concerns the article on child labor by Jonah and Abebe (2019). They argue that the mining income of youngsters between 14-17 years is crucial to the livelihoods of poor households. Another study reports on the – usually contested – implications of Chinese involvement in *galamsey* (Aidoo, 2016). It contends that the loans for infrastructure and energy development negotiated in return for access to mining and other natural resources were a great incentive to Ghana's economy, as is access to the Chinese market.

5.5. Personal insecurity

Three forms of personal insecurity emerge from the review. The first is due to violent encounters arising from both ASM and LSM. The causes of such violent encounters are fourfold. First, they occur between armed illegal small-scale miners and a military task force combatting illegal mining (Botchwey et al., 2019; Eduful et al., 2020; Hirons, 2014; Ofosu-Mensah, 2017). Second, there are tensions with Chinese miners, who use armed force to defend their access to resources (Antwi-Boateng and Akudugu, 2020) and confront community upheavals. Such revolts are caused by mistreatment of Ghanaian workers, cultural differences, conflicts over land, and adverse environmental effects (Aidoo, 2016; Armah et al., 2013; Hilson et al., 2014). Third, violent clashes occur between local communities and security guards of LSM companies over access to land or dissatisfaction about a lack of employment (Guo, 2019; Schueler et al., 2011). Sometimes discontent is directed toward security agencies responsible for law enforcement, as in the case of owners of buildings that had suffered blasting damage, who considered the local security agency as a complicit of the mining company for not stopping the use of dynamite (Baah-Ennumh and Forson, 2017). The fourth cause of violence is transitory or migratory mining, which attracts armed robbers who threaten the security of both miners and nearby communities (Nyame and Grant, 2014). The second type of personal insecurity relates to anxiety about the consequences of mining, such as land grabbing (Hausermann et al., 2018), work pressure, and poor and unsafe labor conditions (Amponsah-Tawiah et al., 2013). Related to this, Antabe et al. (2020) refer to 'solastalgia': distress about environmental change and associated health risks (see also 5.2). Underground blasting activities create the third form of personal insecurity, rendering dwellings unsafe (Baah-Ennumh and Forson, 2017).

5.6. Community insecurity

The reviewed literature points toward several causes of community insecurities. Table 7 shows that these revolve around elite capture, child labor, school dropout, increasing inequalities, discrimination and conflicts, threats to traditions and culture, and displacement (usually associated with LSM). Five articles point to elite capture (see references in Table 7), commonly local chiefs who benefit from payments by (Chinese) miners and mining companies without adequately investing in community development projects. This results in limited attention to structural problems in their community, such as youth unemployment, illiteracy, and growing crime rates (Eduful et al., 2020), and compromises their power to enforce mining laws in their jurisdictions (Ofosu-Mensah, 2017).

Limited schooling and unemployment drive youth into *galamsey* (Eduful et al., 2020). The 'quick money' (Antwi-Boateng and Akudugu, 2020; Azumah et al., 2020; Baah-Ennumh and Forson, 2017) draws

Table 7
Community insecurities addressed in the reviewed articles (n=23)

Issues leading to community insecurity	References & focus		
	LSM	ASM	Both
Elite capture (n=5)		(Antwi-Boateng and Akudugu, 2020; Hausermann et al., 2018; Hilson et al., 2014; Ofosu-Mensah, 2017)	(Armah et al., 2013)
Child labor/school dropout (n-4)[a]		(Antwi-Boateng and Akudugu, 2020; Azumah et al., 2020; Eduful et al., 2020; Hirons, 2014)	
Increasing inequalities /discrimination/ conflicts (n=9)	(Agyei-Okyere et al., 2019; Guo, 2019; Moomen and Dewan, 2016)	(Aidoo, 2016; Arthur-Holmes and Abrefa Busia, 2020; Botchwey et al., 2018; Hausermann et al., 2018)	(Armah et al., 2013; Patel et al., 2016)
Threats to traditions & culture (n=5)	(Antwi et al., 2017)	(Antwi-Boateng and Akudugu, 2020; Hausermann et al., 2018)	(Antabe et al., 2017; Kumah and Adum Nyarko, 2018)
Displacement (n=4)	(Antwi et al., 2017; Wan, 2014)		(Antabe et al., 2017; Kumah and Adum Nyarko, 2018)

[a] But see Jonah and Abebe (2019), Kumah et al. (2020), and Zolnikov (2020).

youth away from farming, community projects, and school (Antwi--Boateng and Akudugu, 2020). Child labor and school dropout are common in gold-mining areas (Antwi-Boateng and Akudugu, 2020; Azumah et al., 2020; Eduful et al., 2020; Hirons, 2014). Evidence is not conclusive, however. Several authors argue that female involvement in ASM enables them to pay school fees for their children (Kumah and Adum Nyarko, 2018; Zolnikov, 2020). Also, Jonah and Abebe (2019) argue that youth engagement in ASM enables them to finance their educational needs while boosting their self-confidence and teaching them skills they do not learn in school.

The bulk of the articles addressing community insecurities focus on discrimination, growing inequality, and conflict. Arthur-Holmes and Abrefa Busia (2020) point to discriminatory practices among ASM operators, who pay women belonging to the same ethnicity as themselves earlier or better than other women, thus creating tensions within the community. Anti-Chinese sentiments in communities emerge where local miners compete with better-equipped Chinese miners to access mining resources (Aidoo, 2016). Growing inequality originates from unequal treatment of marginalized people like women of other ethnicities (Arthur-Holmes and Abrefa Busia, 2020), disabled people (Agyei-Okyere et al., 2019), women and youth with marginal positions in *galamsey* (Botchwey et al., 2019), and migrant sharecroppers without secure tenure who are expelled from their land to make place for mining (Hausermann et al., 2018). Where mining companies cooperate with District Assemblies to implement community development projects, growing inequality may arise between communities if these projects are restricted to communities in the company's sourcing area (Guo, 2019). In addition to conflicts over access to mining resources (Aidoo, 2016; Patel et al., 2016), there are conflicts over access to land (Armah et al., 2013; Hausermann and Ferring, 2018) and other natural resources located in concessions, such as shea trees in northern Ghana (Moomen and Dewan, 2016).

Five articles address threats to tradition and culture. Kumah and Adum Nyarko (2018) draw attention to the loss of cultural heritage due to mining. They note that digging destroys local ceramics and other archeological artifacts as well as 'contextual evidence', which compromises archeologists' ability to reconstruct people's history and past lifestyles. Similarly, digging for gold at old burial sites and shrines is disrespectful of ancient African belief and practice of ancestral veneration and disconnects people from their ancestors (Antwi et al., 2017; Kumah and Adum Nyarko, 2018). Hausermann et al. (2018) point to the disruption of traditional solidarity arrangements such as communal labor. Community members no longer want to contribute as they feel aggrieved about the chief taking all royalties without adequately investing in community projects. Antwi-Boateng and Akudugu (2020) highlight that Chinese prevalence in the ASM sector compromises traditional values by introducing illicit gambling (slot machines) and prostitution in the communities. The latter is partly associated with women trafficking from China (Antwi-Boateng and Akudugu, 2020; Antwi et al., 2017).

Finally, human insecurity issues arise from forced displacement without adequate compensation (Antabe et al., 2017; Antwi et al., 2017; Kumah and Adum Nyarko, 2018; Wan, 2014). Citing data from Mining Watch Canada, mining alone has displaced more than 30,000 people from the Prestea area between 1990 and 1998 (Kumah and Adum Nyarko, 2018). In addition to mining, people also need to resettle because of mining-related infrastructural development (Antwi et al., 2017). The dislocation touches various dimensions of human insecurity: economic due to the loss of livelihoods; and community insecurity due to the loss of a cultural sense of belonging and place and disconnection with ancestors; a relative increase of vulnerable groups (youth, elderly, women, disabled) as others migrate to compensate for lost livelihoods; and a hostile relationship between the non-resettled communities and the mining company (Antabe et al., 2017; Antwi et al., 2017).

5.7. Political insecurity

Political insecurity — disrespect of fundamental human rights and the rule of law (Table 1) – was the least addressed human security dimension in the reviewed articles (10 papers), with attention mainly focusing on threats to the rule of law. In ASM studies, the main issue of concern is endemic corruption (Botchwey et al., 2019: 321) at multiple levels, often explicitly related to the role of Chinese immigrants in *galamsey* (Aidoo, 2016; Antwi-Boateng and Akudugu, 2020; Armah et al., 2013; Botchwey et al., 2019; Hilson et al., 2014). Such corruption starts with immigration officers taking bribes to provide the Chinese with proper documentation (visa, work permit) or to extend their stay, thus ignoring the illegality of their engagement in *galamsey* (Antwi-Boateng and Akudugu, 2020; Armah et al., 2013; Hilson et al., 2014). Bribing of task forces and police officers in charge of taking action against illegal mining also occurs so that they 'look the other way' or follow a 'catch and release' pattern toward the arrestees (Eduful et al., 2020), which leads to a situation of impunity and 'out of control' government (Botchwey et al., 2019). At the community level, some traditional authorities are blamed for taking bribes in return for allowing Chinese and other illegal miners to work in their area of jurisdiction, using the money for self-enrichment rather than investing in community development (Aidoo, 2016; Antwi-Boateng and Akudugu, 2020; Eduful et al., 2020; Hausermann et al., 2018; Hilson et al., 2014). In this respect, Aidoo (2016) noted that local elites benefit from *galamsey* by investing in income-generating ventures such as the rental of excavators, tractors, and standby generators, contributing to their self-enrichment. The widespread corruption compromises the political will to enforce the law (Armah et al., 2013), but also the weakness of local government structures and structural understaffing of the responsible government agencies play a role in this regard (Armah et al., 2013; Guo, 2019; Wan, 2014). Regarding the latter, Guo (2019) points to the pressure on the budgets of district assemblies due to the growing influx of people in ASM and associated waste management and security issues.

Studies on the LSM sector focus more on procedural injustice

regarding compensation and resettlement. This is attributed to weak expertise, knowledge, and negotiation skills at the community level and the eroded power of chiefs in resettled communities (Antwi et al., 2017; Wan, 2014).

Do widespread corruption and poor law enforcement in the mining sector indicate that Ghana is a weak state without the rule of law? Antwi-Boateng and Akudugu (2020) argue that the influx and dominance of the Chinese in ASM and their way of using bribery undermine Ghana's sovereignty. Others point toward actions such as the "military-style operations undertaken by the Inter-Ministerial task force in mid-2013 and again with the moratorium and Operation Vanguard in 2017 and 2018" (Botchwey et al., 2019: 321) and arrests of Chinese and their deportation to China (Armah et al., 2013) as counter-proofs of Ghana being a weak or failed state. Instead, they argue that corruption is an explanation in its own right for the state's regulatory ineffectiveness. Antwi-Boateng and Akudugu (2020) agree to some extent where they say that "[i]n the case of Ghana, the country does not lack institutions, but rather these institutions have been compromised by corrupt and rent-seeking elites who abuse these institutions for selfish gains" (p. 148). However, corruption may lead to political and other human insecurities, for example, when non-enforcement of mining regulations leads to violation of environmental laws and causes water pollution (Armah et al., 2013).

5.8. Gender insecurity

The literature on gold mining in Ghana reveals increasing attention to the gendered aspects of mining, generating insights into the gender dimension of human (in)security. Most of these studies (14 of 15) focus on ASM, acknowledging that there is hardly a place for women in the LSM sector except for indirect job opportunities in the service sector (Benshaul-Tolonen et al., 2019), whereas *galamsey* offers income-generating opportunities for women. They work in the pits, together with men, as traders of food items, water, and mobile phone credit, or providers of cooking, washing, and cleaning services (Long et al., 2013; Ofosu-Mensah, 2017). As such, they support their families – implying that the ban on ASM deprived them of these income-generating activities, compromising their ability to pay school fees and food (Zolnikov, 2020). However, their involvement in the ASM sector is driven by poverty and a lack of alternative income-generating opportunities. This confines them to the most marginal and lowest-paid tasks such as digging, carrying and washing sediment, stirring gold, and shallow pit mining, denying them access to digging tools such as pick-ax and hammer (Koomson, 2018; Kumah et al., 2020). In this way, female work in the mining sector reproduces gender roles and associated inequities, leading to cultural marginalization, limited rights and support services, and a lack of say in decision-making and management of ASM sites (ibid.).

As already noted related to economic, food, and health insecurity, the adverse effects of mining hit women harder than men. This was found for working conditions and mercury exposure (Armah et al., 2016a, 2016b; Ferring and Hausermann, 2019), and for compensation for crop damage, which exists for cocoa trees, but rarely for the food crops that women grow (Hausermann et al., 2018). In northern Ghana, women are denied access to shea trees in mining concessions (Moomen and Dewan, 2016). This loss of access and its effects on shea-manufacturing and the wholesale and retail sectors prejudice women the most. Moreover, women face disproportionate risks of injuries due to the kind of tasks they perform (Calys-Tagoe et al., 2017, 2015). An explanation of the latter is, however, not given: the authors identified excavation (58.7%) and crushing (23.1%) as the most injury-prone activities, whereas these tasks are not carried out by women (Ibid). Neither do women have less experience in mining (Armah et al., 2016b) – another factor influencing the occurrence of injuries (Calys-Tagoe et al., 2015). However, other health issues are related to the gender division of labor in mining. The nature of their work in ASM brings women more often than men in direct contact with sediments, resulting in disproportional exposure to mercury (Ferring and Hausermann, 2019). Continuous carrying head-loads of sediment results in waist pain, (severe) headaches, and back and foot pain (Arthur-Holmes and Abrefa Busia, 2020). Women also face harder psychological challenges due to anxiety about declining water quality and food availability, loss of farming land, and financial stress because of higher health care costs caused by increasing malaria incidence in their children (see also 5.2). These mental pressures, in turn, undermine their own resistance to malaria (Ferring and Hausermann, 2019). Finally, two studies mention the effects of mining on women trafficking from China to satisfy Chinese miners' needs and increase prostitution in mining areas in general, creating gendered human insecurity for both Chinese and local women (Aidoo, 2016; Antwi-Boateng and Akudugu, 2020).

6. Governing mining-related human insecurities

We adapted the typology of governance and regulation approaches by Collins and Lawson (2014) to categorize the governance and policy recommendations suggested in the reviewed papers (Annex 5). We added a category 'Multidimensional/integrated approaches' suggested by 28% of the authors.

6.1. Multidimensional and integrated approaches

Nineteen studies (27.5%) across all mining types (LSM, ASM, or both) recommend a comprehensive approach to tackle the identified issues (Annex 5). Most proponents of these approaches (79%) acknowledge that solutions for adverse impacts require addressing the broader development and employment[8] needs and rights of rural people (Eduful et al., 2020; Hilson et al., 2013; Hirons, 2014; Moomen and Dewan, 2016; Osei-Asare et al., 2018). Some of these focus on specific target groups such as disabled people (Agyei-Okyere et al., 2019) or youth of school-age (Azumah et al., 2020; Jonah and Abebe, 2019), or refer to the need to relate mining policies to Ghana's emission reduction commitments (Amoako et al., 2018). Recognizing the importance of ASM for rural livelihoods, particularly in northern Ghana, Hilson et al. (2013) argue for a re-orientation of the farm focus in rural development policies and integration of ASM in the national poverty alleviation strategy. Ofosu-Mensah (2017) argues that creating employment is a more effective strategy than the military-style approach to combating illegal mining that the Ghana government follows (see 7.1).

Remarkably, all studies that employed GIS recommend integrated approaches, acknowledging that the mining sector is embedded in multidimensional livelihoods (Moomen and Dewan, 2016) and multifunctional landscapes (Antwi et al., 2017; Obodai et al., 2019; Schueler et al., 2011). They generally advocate land-use planning to ensure greater protection of forests and farming land (Antwi et al., 2014; Awotwi et al., 2018; Kyerematen et al., 2020; Moomen and Dewan, 2016) or an integrated water resource management plan (Obodai et al., 2019).

The remaining studies in this category recommend multidimensional but sectoral approaches. Among these are proposals to combine regularization with training and clean-ups of oil and grease spills (Mantey et al., 2020). Others suggest addressing the broader context of institutional weakness and corruption to reduce the illegal immigration of Chinese immigrants (Antwi-Boateng and Akudugu, 2020). Another recommendation is to combine the formalization of the ASM sector with specific attention to the psychological and developmental effects of

[8] Creating employment and alternative livelihoods is a separate category in Collins and Lawson's typology (2014), but has been included here. Two other studies recommending employment or alternative livelihoods did so in combination with a proposal for formalization and regulation (Baah-Ennumh and Forson, 2017) and gender-focused initiatives (Kumah et al., 2020).

mining on women and children (Zolnikov, 2020). Two health studies recommend paying explicit attention to the psychological effects of mining, alongside awareness raising, enforcement of the International Labour Organization's Safety & Health in Mines Convention 1995 (No. 176), and integration of communities in health assessments (Amponsah-Tawiah et al., 2014; Antabe et al., 2017).

6.2. Strategies focused on mercury, heavy metals, and radionuclides

In line with the relatively large number of studies focusing on mercury use and heavy metal pollution, a substantial proportion (23.2%) recommend strategies to deal with mercury use, heavy metal pollution, and radiation risks. Recommendations regarding mercury – all referring to ASM – include adopting and imposing guidelines on mercury management (Affum et al., 2016; Gyamfi et al., 2021; Kwaansa-Ansah et al., 2019), greater control and monitoring of ASM activities (Affum et al., 2016; Kwaansa-Ansah et al., 2019) – including the use of PPE (Afrifa et al., 2018; Armah et al., 2016a); awareness raising of occupational risks and the use of contaminated food and water (Armah et al., 2016a; Kwaansa-Ansah et al., 2019); and a systematic approach to phase out mercury in ASM (Armah et al., 2016a; Gyamfi et al., 2020).

Suggestions to tackle heavy metal pollution revolve around four main strategies, with none of these explicitly referring to LSM or ASM. Several authors recommended remediation actions (Affum et al., 2016; Foli and Nude, 2012), with some specifically suggesting phytoremediation by stimulating the growth of ferns or other soil covers (Amoakwah et al., 2020; Bempah and Ewusi, 2016; A.K. Mensah et al., 2020). Another suggestion is to increase control and monitoring (Affum et al., 2016; Armah and Gyeabour, 2013; Bempah and Ewusi, 2016), with Long et al. (2013) and Antabe et al. (2017) explicitly making a case for community participation in environmental monitoring and health assessment. The third strategy centers on awareness raising regarding PPE use and how to deal with contaminated fish (Gbogbo et al., 2018) and water (Bempah and Ewusi, 2016; Bortey-Sam et al., 2015a). Finally, several authors recommend direct interventions by the government to provide clean potable water (Bortey-Sam et al., 2015a; Long et al., 2013) and discourage alluvial mining (Affum et al., 2016).

Only two studies examining radionuclide concentrations provide recommendations in this respect. One of them recommends periodic monitoring for airborne radon (Faanu et al., 2011), while the other recommends limiting the number of workers and the time spent in the processing of sulfide ore for gold to keep the exposure to radiation as low as possible (Gbadago et al., 2011a).

6.3. Formalization and regulation of the ASM sector

The Mercury Law, Small-Scale Gold Mining Law, and Precious Minerals and Marketing Law sought to formalize the ASM sector in Ghana in 1989 (Hausermann et al., 2018). However, several authors question whether formalization of the ASM sector has any chance to succeed, considering that miners in this sector are mainly 'necessity entrepreneurs' without a mining background who engage in mining for lack of other opportunities. Considering the lengthy and costly bureaucratic procedures to obtain a permit, the lack of political and financial support, and the capital needed to operate according to the rules, it is most likely that *galamsey* will continue to occur in 'informal spaces' (Hilson et al., 2017, 2014; Hilson and Maconachie, 2017). However, 13% of the reviewed studies consider formalization and regulation of the ASM sector and more control and law enforcement (5.8%) as the most desirable way forward. For instance, Calys-Tagoe et al. (2017) show that workers in licensed operations have lower injury profiles than those in unlicensed operations. Hence their support to the recommendation in the Minamata Convention on Mercury (Annex C 1c), which states that the ASM sector should be formalized and regulated to improve miners' working conditions. Other authors also support this proposition (Baah-Ennumh and Forson, 2017; Clifford, 2017; Zolnikov, 2020). Regulation and revision of laws are also proposed (i) to cope with the growing immigration and domination of Chinese investors and miners in ASM (Armah et al., 2013; Botchwey et al., 2019) and within-country migration flows of *galamsey* miners (Nyame and Grant, 2014); (ii) to assign a more significant role for district governments in regulating and monitoring ASM (Guo, 2019); and (iii) to deal with gender inequality in mining(Arthur-Holmes and Abrefa Busia, 2020; see 6.7). Others point to the need to enforce existing laws regarding the reclamation and rehabilitation of mined land (Asamoah et al., 2017; Awotwi et al., 2017; Botchwey et al., 2019; Okyere and Nortey, 2018).

6.4. Training, capacity building, and awareness raising

Recommendations referring to training, capacity building, and awareness aising (11.6%) mainly relate to safety in the use of PPE and mining equipment, both in LSM (Ayaaba et al., 2017) and ASM (Calys-Tagoe et al., 2015; Kortei et al., 2020; Mensah et al., 2016; Nakua et al., 2019a, 2019b). Others point to the necessity of raising awareness about drinking contaminated water, whereby the distinction between LSM (Bortey-Sam et al., 2015a) and ASM (Ansa-Asare et al., 2015) is less relevant. A study on occupational respiratory diseases in two large-scale gold mines argues for more education and research on mining-related diseases (Ayaaba et al., 2017).

6.5. Knowledge-based strategies

Knowledge-based strategies in the typology of Collins and Lawson (2014) comprise the collection of reliable national and local data on mining, sharing of knowledge, and local-level community engagement, participation, and dialogue. Among the reviewed articles embarking on such a strategy (8.7%), three recommend research into mining-related diseases, specifically on the causes of pulmonary and respiratory diseases (Rajaee et al., 2017) and the relationship between toxic chemicals and associated diseases among rural farmers and ASM operators (Obiri et al., 2016b), and the link between adverse human health and large-scale gold mining (Armah et al., 2012). Aragón and Rud (2016) recommend research into the adverse impact of LSM on agricultural productivity and farmers' income during environmental assessments.

6.6. Reclamation and clean-ups

Six studies (8.7%) recommend reclamation and clean-ups of mining sites and more law enforcement in this regard. This recommendation was made across studies focusing on LSM (Amoako et al., 2018; Antwi et al., 2017; Kyerematen et al., 2020), ASM (Awotwi et al., 2017; Botchwey et al., 2019), or both (Okyere and Nortey, 2018).

6.7. Gender-focused initiatives

Five studies (7.2%), all focusing on ASM, propose gender-focused initiatives, three of which target national policies, one the working place, and one a collaboration between the two. Those addressing national policies make clear that the ban on ASM hits women (and indirectly their children) the hardest, as mining is women's major income-earning opportunity in areas where ASM prevails (see 5.8). Losing that income negatively affects household food security and children's health and education as there will be insufficient money for food, health expenditures, and school fees (Kumah et al., 2020; Zolnikov, 2020). Koomson (2018) advocates a policy change that enables women to acquire and own mining pits to avoid gender-based inequality (see 5.8). Recommendations targeting the workplace suggest dealing with gender-based inequalities and discrimination and creating gender-sensitive support services and work conditions that minimize occupational injuries and exposure to contamination (Armah et al., 2016b; Arthur-Holmes and Abrefa Busia, 2020). Arthur-Holmes and Abrefa Busia (2020) advocate collaboration between the district

government and mining companies to create gender-sensitive policies and regulations.

6.8. Managing the intersection of ASM and LSM

Only two studies (2.9%) address strategies to manage the intersection of ASM with LSM. Patel et al. (2016) recommend that due attention be given to ASM when mining concessions are allotted in areas where ASM occurs to avoid conflicts between ASM and LSM. Wan (2014) cautions against prioritizing foreign direct investment in LSM over local and national interests.

7. Discussion

7.1. A human security perspective: holistic but a potential securitization trap

This review of 97 peer-reviewed papers published between 2011-2020 used the human security dimensions of the UNDP (1993, 1994) to analyze the impacts of gold mining in Ghana. In contrast with a state-focused definition of security, human security represents a more people-centered approach that focuses on people's wellbeing and their right to be 'free from want and fear' (Hanlon and Christie, 2016; UNDP, 1994, 1993).

A human security approach to mining is relatively new. Engwicht and Grabek (2019) propose it as a counternarrative to a discourse that centers on increasing legalization and transparency. They advocate a human security approach to examine how mining and natural resource governance reforms impact the lives, wellbeing, and security of populations affected by extractive industries. In doing so, they acknowledge that despite efforts toward good governance in the mining sector of Sierra Leone, formalization schemes have not led to tangible changes in the quality of life of ASM workers in particular. As such, human security becomes a governance indicator (I. Mensah et al., 2020), based on the underlying notion that mining involves "numerous human security threats and concerns" (Ibid, p. 81). Used in this way, Johnson (2019) concludes for Sierra Leone and Ghana that:

"Paradoxically, the presence of institutions thought to be necessary for fostering human security appears in many ways to be producing the opposite effect: greater human *in*security"(Johnson, 2019: 432).

For this reason, we framed the human security dimensions in this paper as *in*securities. The review indeed revealed that the articles reported more human insecurities than securities associated with gold mining. The latter concerns mainly short-term economic security for rural people, including women and youth. However, this was outnumbered by the accounts on insecurities in all human security dimensions: environmental insecurities associated with land degradation, deforestation, biodiversity loss, and pollution of drinking water; health insecurities associated with heavy metal pollution, mercury intoxication, greater incidence of malaria, occupational injuries, and psychological distress; food insecurity due to irreversible damage to farming land, pollution, and disruption of local food markets; economic insecurity due to land degradation and – in the case of LSM – relocation; personal insecurities due to violent conflicts and anxiety associated with the effects of gold mining; community insecurity due to inequalities, elite capture, conflicts, school dropout, relocation, and tense relations with (notably Chinese) immigrants; and political insecurity due to corruption and a lack of political will to enforce the law. Gender insecurity emerges through discrimination at the workplace (unequal access to resources and tools; women being more vulnerable to occupational hazards and injuries); inadequate compensation for the loss of food crops; and the ban on ASM, which deprived women of one of the few income-generating opportunities that enabled them to pay for school fees and their children's food and health security (see 5.6). Considering that the adverse effects of mining hit women harder than men, we argue that the gender dimension should be separated from the personal dimension of human security.

Although analyzed separately, these human insecurity dimensions are intrinsically related and cannot be considered in isolation of each other. Examples abound: environmental insecurities (pollution, land degradation) leading to health, economic, and food insecurity; political insecurity (the compromised rule of law, corruption) affecting environmental insecurity (e.g., neglect of environmental regulations), personal insecurity (e.g., military-style interventions), and community insecurity (e.g., related to immigration of Chinese and illegal immigrants); and gender insecurity leading to economic, food and health insecurity.

A human security approach allows for a comprehensive analysis of multiple and interrelated dimensions of gold-mining impacts that we have not seen in the reviewed studies. Another advantage is that framing threats as insecurities creates a sense of urgency to act (Fischhendler and Katz, 2013). However, there are two risks involved in using such a rhetorical device. The first is the risk of inaction: "If everything is a matter of security, then how does one choose in cases demanding trade-offs?" (ibid., p. 325). Second, there is a risk of falling into the 'securitization trap'. Several studies referring to human security narrowly interpret the concept as insecurity caused by violent actions of paramilitaries, mine security personnel, government agencies combatting illegal mining, or armed thugs (Bond and Kirsch, 2015; Nyame and Grant, 2014; Rochlin, 2015). Indeed, framing adverse effects as 'insecurities' may lead to painting illegal mining, particularly, as a 'menace' justifying a military-style approach like *Operation Vanguard* in Ghana to 'solve' the problems associated with unlicensed *galamsey* operations (Eduful et al., 2020; Hilson and Maconachie, 2020). Such military and police interferences contribute to personal and political insecurities through the confiscation, burning, and destruction of equipment, arrests, and removal of minor operators, who depend on ASM for their livelihoods (Eduful et al., 2020). Rather than a military-style and securitization approach to the mining sector, several authors emphasize the need to understand the complexity of *galamsey* (Eduful et al., 2020) and why people engage in illegal mining in the first place (Ofosu-Mensah, 2017). As proposed in this and other papers in this special issue[9] (Calvão et al., 2021; Schilling et al., 2020), a human security approach in the broad sense of the word does justice to the multidimensional nature of illegal mining and adverse mining effects.

7.2. Limitations of the research

Several limitations to this review need to be mentioned. First, this is not a full-fledged systematic literature review because the search process was done by the first author only, and the assessment of included studies for methodological rigor was omitted. We compensated for the first by developing a template for screening and analysis, based on which the co-authors each analyzed a part of the included studies. The first author checked the screening to guarantee consistency of the analysis and internal reliability. The lack of methodological assessment was compensated by including only articles from journals with a proper review process, implying that we excluded grey literature, documents from institutional databases, and articles from journals on Beall's list of predatory journals. We may have missed relevant insights from practitioners and policymakers by excluding grey literature and literature from international organizations.

Second, three types of biases (Booth et al., 2012) may have occurred in this review. A *database bias* may have led to underreporting studies from journals from developing countries (Booth et al., 2012). As explained, we focused on the Web of Science and Scopus for being established databases, with a certain degree of guarantee of the quality of the peer-review process. Journals from developing countries are often not covered by these databases. This was compensated to some extent by

[9] Two other papers are still under review at the time of this writing.

including African Journals OnLine (AJOL) journals in Scopus.

A *selection bias* may have occurred through the focus on studies based on primary data. This may explain the dominance of environmental and health studies (respectively 74% and 62% of the reviewed studies) and a relative underrepresentation of studies focusing on personal and political insecurity, on which it is hard to collect primary data due to the sensitiveness of these topics. The focus on primary research also implies that review and opinion pieces have been excluded, despite their potentially valuable insights. Several such papers have been published in this journal (e.g., Ayelazuno, 2014; Hilson, 2016; Hilson, 2020). Finally, a selection bias may have occurred regarding community-company relations. That is because we excluded papers on corporate social responsibility, specific projects, and compensation programs (e.g., Andrews, 2016; Armah et al., 2011; Boadi et al., 2018; Hilson et al., 2019; see exclusion criteria in Table 3) and on mining companies' contribution to the Sustainable Development Goals (e.g., Kumi et al., 2020). This may have led to underreporting of cooperative and friendly relationships.

Finally, there is a potential *duplicate publication bias* due to multiple papers being based on a single study. Such duplicate publications were mainly about mercury and heavy metal pollution, radionuclides, and occupational health/injuries. Since we did not draw conclusions on the frequency of occurrence, we feel this bias does not influence the conclusions.

7.3. Identified knowledge gaps

Based on the review, the principal research gap concerns the personal and political insecurities which receive the least attention in the literature (16% and 10%, respectively) – irrespective of whether the studies focus on ASM or LSM. This is remarkable, seeing that violent encounters and fatal accidents are frequently reported in the media. As far as the underrepresentation of studies on personal insecurities is concerned, the selection bias mentioned above plays a role: data on violent encounters and fatal injuries is hard to collect through primary research. Analyses of media reports or medical records were excluded for not being based on primary sources but provide insights into fatal injuries. For instance, an analysis of media reports between 2007-2012 revealed that 97% of reported accidents occurred in ASM operations, with entrapment due to a collapsed mine pit and violent clashes between miners and other groups accounting for 22% and 19% of the reported accidents respectively (Kyerematen-Amoah and Clarke, 2015). An analysis of injury statistics of the Ghanaian entire mining industry from 2004 to 2015 revealed that more people were fatally injured than nonfatally injured, while incidents/accidents data from five LSM companies showed 30 fatalities (15%) versus 172 nonfatal injuries (85%), with 90% of the fatalities involving equipment (Stemn et al., 2019). Despite the exclusion of such studies, several reviewed studies report violent encounters involving mining gangs (Nyame and Grant, 2014), armed ASM operators (Aidoo, 2016; Antwi-Boateng and Akudugu, 2020; Eduful et al., 2020), concession guards (Guo, 2019; Schueler et al., 2011), and the military taskforce (Botchwey et al., 2019; Eduful et al., 2020; Ofosu-Mensah, 2017; Wan, 2014).

Underreporting of political insecurities may be due, first, to the sensitivity of issues like corruption and lack of law enforcement. Second, unlike health and environmental insecurities that can be directly attributed to mining, political insecurities such as the lack of enforcement of the rule of law, corruption, and a lack of access to justice are endemic and not specific to the extractive sector.

A second knowledge gap concerns the lack of attention to integrated approaches to address mining-related insecurities at the landscape level. It is to those that we turn in the next section.

7.4. Governing insecurities: toward an integrated landscape approach?

Annex 5 and Section 6 revealed an overwhelming focus on sectoral policy recommendations. However, gold mining is embedded in multidimensional livelihoods and multifunctional landscapes. This implies that the challenges outlined in this paper cannot be addressed from a sectoral perspective alone. A growing body of literature, therefore, argues in favor of integrated approaches that look beyond the mining sector and propose solutions that are embedded in broader rural development strategies (Agyei-Okyere et al., 2019; Eduful et al., 2020; Hilson et al., 2013; Hirons, 2014; Moomen and Dewan, 2016; Osei-Asare et al., 2018).

Remarkably few studies advocate integrated landscape approaches in the sense of those promoted by Sayer et al. (2013) and Reed et al. (2020a, 2020b). Such approaches are a form of multistakeholder, multisector landscape governance. Central in integrated landscape approaches is the deliberation and negotiation of trade-offs between multiple land uses (notably development-environment trade-offs). They aim to address multiple challenges such as land and forest degradation, food insecurity, climate change, and biodiversity loss in a holistic manner and achieve multifunctional, resilient, and sustainable landscapes (Reed et al., 2020a, 2020b, 2016; Ros-Tonen et al., 2018; Sayer et al., 2013). Key in such approaches is the involvement of multiple stakeholders (Sayer et al., 2013), similar to trends in agriculture (e.g., Thorpe et al., 2021; van Ewijk and Ros-Tonen, 2021) and forestry (e.g., Moog et al., 2015; Sarmiento Barletti et al., 2020). Approaching 'wicked' problems (Rittel and Webber, 1973)[10] from a human security perspective, as we have done in this paper, makes multifaceted problems more concrete and closer to the realities and lived experiences of the stakeholders involved. This facilitates identifying 'common concern entry points' (Sayer et al., 2013) around which the stakeholders can take collective action. Without explicitly referring to the literature on integrated landscape approaches, three studies in our review proposed an integrated strategy articulated around several key elements of such an approach (Antwi et al., 2017; Hirons, 2014; Schueler et al., 2011). They propose a holistic approach that breaks existing sectoral 'silos' to address the causal chain of mining-related human insecurities.

In Ghana, experience has been gained with multistakeholder dialogues through several initiatives. One of these, coordinated by Tropenbos Ghana, focused on combatting illegal logging and chainsaw milling (Parker Mceown et al., 2013). More recently, the Centre of International Forestry Research (CIFOR) has launched a broad partnership to operationalize and implement an integrated landscape approach in northern Ghana (Bayala et al., 2020). However, literature advocating to address mining 'insecurities' through an integrated landscape or jurisdictional approach is scarce (with Langston et al., 2015 among the exceptions). Further (action) research is needed to determine whether such integrated landscape approaches are feasible in mining landscapes.

8. Conclusion

This paper combined a systematic literature review with a human security approach to analyze the impacts of gold mining in Ghana, both artisanal and small-scale (ASM) and large-scale (LSM). We saw that both types of mining generate human insecurities across all dimensions. The reviewed literature focuses primarily on environmental and health insecurities, while personal and political insecurity surprisingly receive the least attention. Most scholarly attention goes to the ASM sector, reflecting its complexity due to the association with poverty and partial illegality. Increasing attention is paid to the gendered impacts of gold mining, the reason why we favor addressing this dimension separately from personal insecurity. Existing literature referring to human security still focuses mainly on violence, risking to fall into a "securitization trap"

[10] 'Wicked' problems are unique, multiscalar and interconnected problems that are a symptom of another problem; have no clear problem formulation; involve multiple stakeholders with conflicting interests; have no true-or-false solution; and are never completely solved (Rittel and Webber, 1973).

that justifies military-style interventions. If used in the multidimensional way as initially defined by the UNDP, a human security approach allows for a holistic analysis of mining impacts and integrated policy responses.

Most solutions proposed to address the *in*securities discussed in this paper are sectoral. However, awareness is growing about the multidimensionality of mining impacts, and more integrated approaches transcending sectoral silos are emerging. Considering the inherent development-environment trade-offs associated with gold mining and the potential conflicts with other land uses, we recommend integrated landscape approaches as potential avenues toward holistic solutions. A human security analysis of mining impacts and trade-offs helps to identify "common concern entry points" (Sayer et al., 2013) in a multistakeholder approach to undertake collective action. Only when the multiple dimensions of mining impacts are recognized and all stakeholders involved in designing solutions can human insecurities arising from gold mining be adequately addressed.

Author contributions

MRT designed the research, developed the protocol for the systematic literature review, and wrote the first draft of the article; JJA, DPS, and MD contributed to the data analysis and the final text.

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Supplementary materials

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